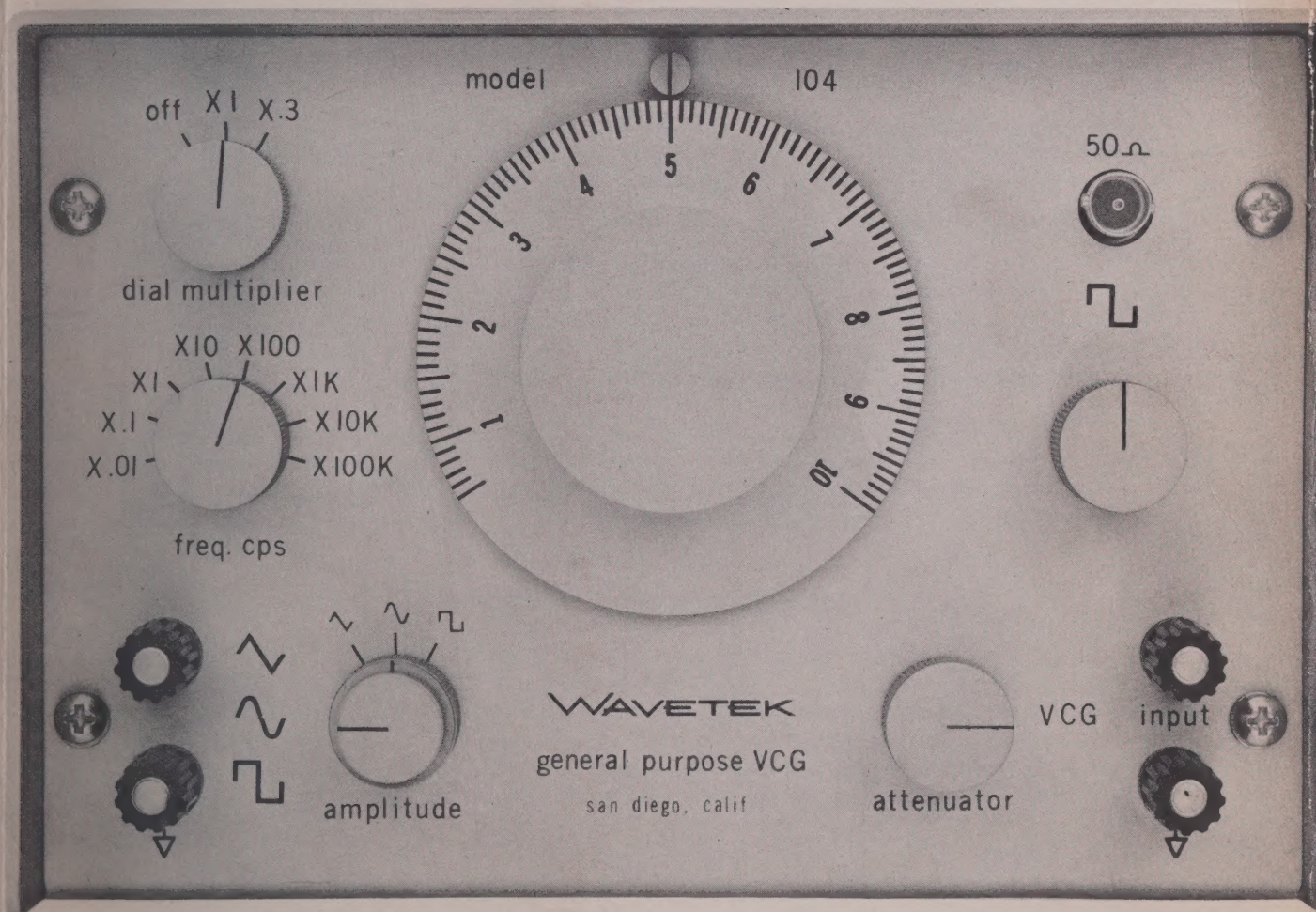
INSTRUCTION MANUAL



MODELS
101, 102, 103,
104, 105
106, 107

WARRANTY

WAVETEK warrants each instrument of its manufacture to be free from defects in material and workmanship. Our obligation under this Warranty is limited to servicing any instrument returned prepaid to our factory for that purpose within one year of delivery to the original purchaser. Serviced instruments are to be returned f.o.b. San Diego, California.

Instruments returned to the factory are accepted only when prior authorization has been given by an authorized representative of WAVETEK.

If the instrument is defective as a result of misuse or abnormal conditions of operation, repairs will be billed at cost. In this event, an estimate will be submitted before the work is started.

SHIPPING INSTRUCTIONS

Depending upon location, the choice of carrier will vary. Never ship an instrument to us without having received shipping instructions. If requested, an estimate of charges can be made before work begins.

Be certain to pack the instrument carefully. The instrument can be placed into a single container, provided it is so packed that it will not shift about. The instrument itself should be first wrapped in paper, or preferably a plastic bag, before packing.

CLAIM FOR DAMAGE IN SHIPMENT

The instrument should be tested as soon as it is received. If it does not operate or is damaged, a claim should be made with the carrier. The claim agent should receive a full report of damage, and this report sent to WAVETEK. After receiving such a report, we will advise you of the disposition of the instrument and arrange for its repair or replacement. Be certain to include model and serial number when corresponding.

TABLE OF CONTENTS

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Section II	Operating Instructions
Section III	Theory of Operation
Section IV	Maintenance
Section V	Parts List
Section VI	Schematic and Parts Location Diagrams
Section VII	Model 106, Model 107 Addendum

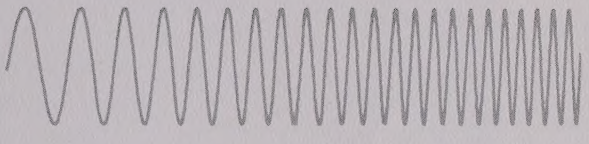
Model 128

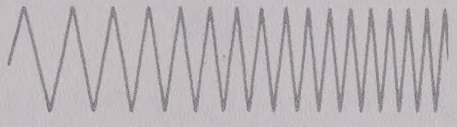
Serial No. 103

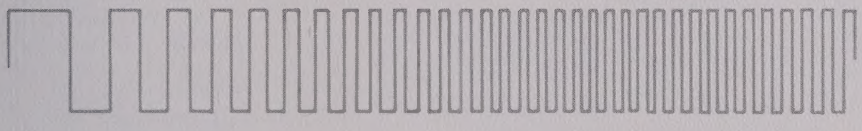
WAVETEK
8159 Engineer Road
San Diego, California 92111
Telephone (714) 279-2200

Dec. 1964

FUNCTION GENERATORS BY WAVETEK







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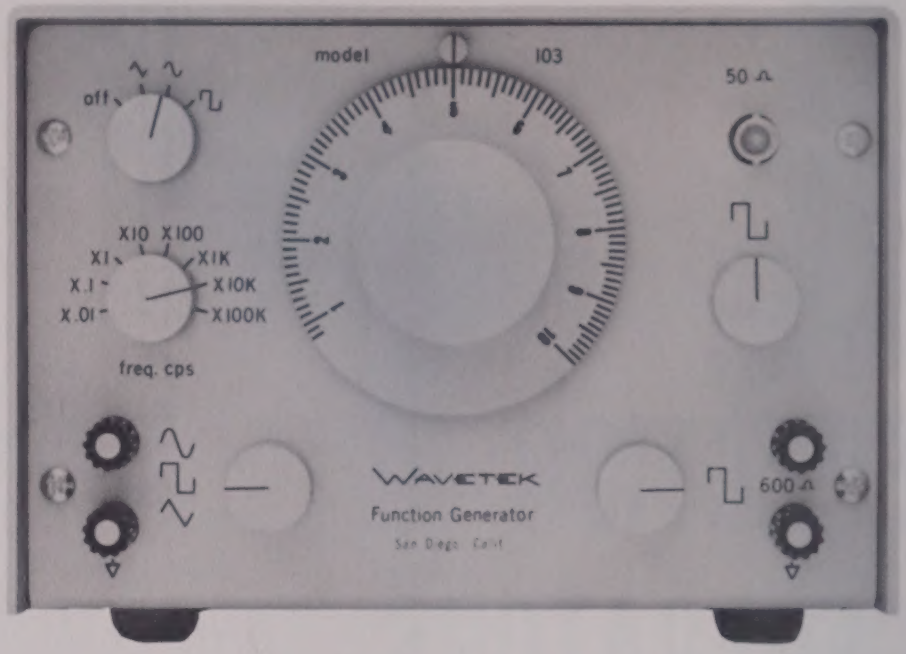


MULTI-PURPOSE FUNCTION GENERATORS

Here's a HANDFUL OF VERSATILITY — three units in one compact case. Function generator . . . oscillator . . . square wave generator. Rugged modular construction, completely solid state, excellent frequency and amplitude stability. Sine wave, square wave, triangle wave — Sophisticated performance for bench or rack mounting with power supply options.

0.008 CPS TO 1 MC

All WAVETEK models feature extremely broad frequency range; clean waveform; flat frequency response; 5 nanosecond rise time and a high frequency triangle wave heretofore unavailable. All WAVETEK models make ideal sources of test signals from servo to video frequencies.

SPECIFICATIONS

Frequency Range: 0.008 cps to 1 mc.

Waveforms: Square, triangle & sine wave. Symmetrical about ground.

Square Wave Distortion: Tilt less than 0.1%. Overshoot and ringing less than 1% for harmonics below 10 mc and less than 5% for harmonics above 10 mc.

Triangle Distortion: Less than 1% for harmonics less than 1 mc.

Sine Distortion: Less than 1% to 10 kc; less than 2% to 100 kc.

Trigger Input: Upon receipt of + or — 5V external trigger (specify), one cycle is generated. If trigger is a long gate pulse, numerous cycles (the length of the gate), will be generated.

Output A: 1 volt p-p, 50 ohms output impedance. Rise and fall time less than 5 nanoseconds independent of frequency.

Output B: ⊓ 10 volts p-p 1%, 600 ohms output impedance. Rise and fall time less than 15 nanoseconds, independent of frequency.

Output C: ∿ 5 volts p-p, 5 ohms output impedance. Current limited to 5 ma.

Output D: ∿ 2 volts rms, or ∿ 5 volts p-p, 5 ohms output impedance current limited to 5 ma.

Output E: ⊓ , ∿ or ∿ . Maximum output 30 volts p-p into 600 ohms load, 50 ohm output impedance, short circuit current ± 100 ma.

Size and Weight: 7¾" W, 5¼" H, 7½" D. Approximately 8 pounds.

POWER SUPPLIES

Option AC: 115 or 230 VAC, 50-400 cps less than 5 watts.

Option R: Nickel cadmium batteries with internal charger. Simultaneous operation and charge. 8 hours operation on batteries between charges. 115 or 230 VAC, 50-400 cps, less than 10 watts.

MODEL		101	102	103	106	107
Outputs Incl.		A,B,C	A,B,D	A,B,E	A,D	A,E
Trigger		No	No	No	Yes	Yes
* Power Option	AC	$395	$495	$595	$595	$695
	R	$475	$575	No	$675	No

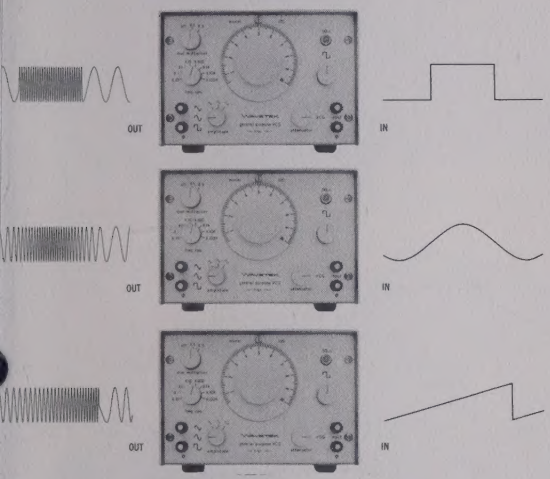
* "D" Battery versions also available.
Prices and specifications subject to change.

WAVETEK

GIANTS

VCG

'OLTAGE CONTROLLED GENERATOR



Here's SOMETHING UNIQUE in signal generating equipment! The WAVETEK models 104 and 105 will generate modulated ∿ , ⊓⊔ , and ∿ waves with any electronic modulating function you can provide . . . all from .0015 cycles to 1 mc. Did you ever want to: . . . fm a servo? . . . sweep test a low frequency filter? . . . spot check a tm channel? . . . sweep test if strips? . . . fm or sweep a triangle wave? . . . fm or sweep a square wave? . . . You can do any or all of these completely electronically with a WAVETEK model 104 or 105. Without external sweep control, it's a general-purpose generator . . . a real handful of versatility.

SPECIFICATIONS

Frequency Range: .0015 CPS to 1 megacycle
VCG Range: 20: 1 max
VCG Input Voltage: 4.75 volts total for 20:1 frequency (full dial spread)
VCG Input Impedance: 10 kΩ minimum
VCG Linearity: ± 1.0% frequency vs. input voltage
Frequency response, accuracy, stability, distortion, outputs, size & weight, same as models 102 & 103

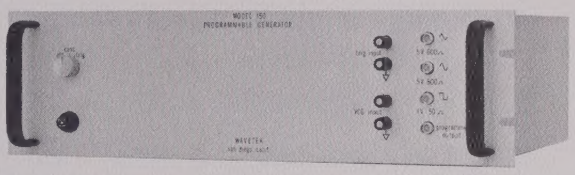
MODEL		104	105
Outputs Incl.		A,D	A,E
Power Supply	AC	$595	$695
	R	$675	No

8133 ENGINEER ROAD
SAN DIEGO, CALIFORNIA
PHONE 714-279-2200

NEW!

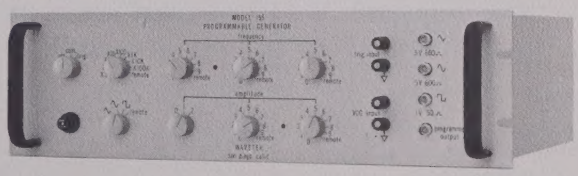
PROGRAMMABLE &

VOLTAGE CONTROLLED FUNCTION GENERATOR



MODEL 150

Frequency Range: .01 cps to 1 megacycle in 8 ranges
VCG Frequency Range: 10:1 maximum
VCG Input Voltage: 5 volts total for 10:1 frequency range
VCG Input Impedance: 10KΩ minimum
VCG Linearity: ± 1.0% frequency vs. input voltage
Accuracy of Programmed Frequency: ±1% of frequency plus 1 digit
Outputs: Fixed amplitude simultaneous Sine, Triangle and Square
Sine and Triangle: 600Ω output impedance—5V p-p.
Square: 50Ω output—1V p-p, 5 nanoseconds rise and fall time max.
Programmed Output: 50Ω output impedance, 10 MV to 10 VPP, 3 ranges, short circuit current ±100 ma.; Square wave rise and fall time, 100 nanoseconds max. max.
Amplitude Stability: ± 1.0% long term; ± 0.1% short term
Frequency Response: ± .1 db to 100 kc; ± 1.0 db to 1 megacycle
Frequency Stability: ± 1.0% long term: ± 0.1% short term
Function Selection: Remote contact closure
Frequency Selection: Three decades contact closure: BCD Code 1248; other codes and logic levels available.
Range Selection: Remote contact closure—8 ranges
Amplitude Selection: Three contact closure: BCD Code 1248; other codes and logic levels available.
Power Required: 115 or 230 vac. ±10%, 50-400 cps approx. 15 watts.
Size and Weight: 5¼" H x 19" W, 16"D for rack or bench use; 10 pounds approximately.



MODEL 155
ALL SPECIFICATIONS SAME AS MODEL 150 WITH LOCAL, FRONT PANEL SWITCHING IN ADDITION TO REMOTE CONTROL CAPABILITY.

AUXILIARY POWER PACK
$595.00

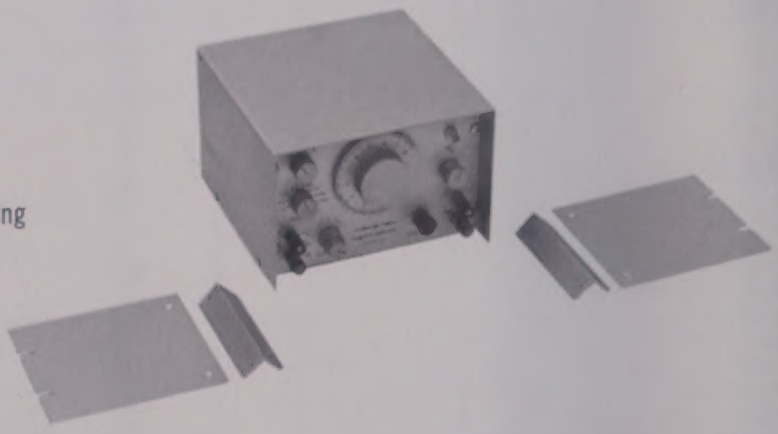
For use with Models 103 and 105, this unit supplies 115AC from a nickel cadmium battery supply and will operate standard AC models for 8 hours in remote locations away from power line. The Auxiliary Power Pack has a built-in charger that will recharge the batteries in 16 hours to full strength after the 8 hour use. Rear input and output connectors, portable models, $25.00 each. Not applicable to 150 series.

RACK MOUNT INSTRUMENTS
$50.00 extra

A 5¼" x 19" panel mounting may be ordered for any WAVETEK instrument by adding $50.00 to the basic price of the desired unit. Rear connectors are included in the Rack Mount price.

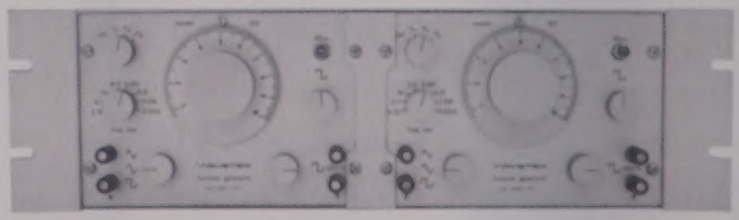
RACK ADAPTER KIT
$15.00

Angle brackets and panels for rack mounting any portable WAVETEK model.



DUAL RACK ADAPTER KIT
$30.00

Angle brackets and panels for rack mounting any two portable WAVETEK models.



FINE ZERO ADJUST CONTROL

Max. 150 mils shift

This control allows exact adjustment of DC output level to ground potential. All models.

$50.00 extra

DC OFFSET ADJUSTMENT

±5v shift

Models 103 and 105. This adjustment allows operation above and below 0V ground potential. This shift, however, limits the p/p output by the amount of offset, e.g., 5v offset limits p/p output to 10v without output amplifier clipping.

$50.00 extra

SPECIAL PAINT

Rack Mount Instruments Only

Customer furnish paint, add $15.00 to Rack Mount price . . .

$65.00 extra

WAVETEK furnish paint, add $50.00 to Rack Mount price . . .

$100.00 extra

SERVICE KIT

Prewired assemblies to allow operation and testing of individual PCB, separate from complete assembly.

$15.00

GENERAL DESCRIPTION

The WAVETEK Models 101/102/103 Function Generators and the 104/105 Voltage Controlled Generators are semi-precision sources of waveforms from servo to video frequencies. These units are extremely rugged, completely transistorized portable packages. Extremely clean and stable waveform signals from .008 cps to 1Mc in the 101/102/103 and from .0015 cps to 1Mc in the 104/105 make all 5 generators versatile, general purpose pieces of equipment for the laboratory or the field.

The Model 101 offers square waves and triangle waves. The Models 102 and 104 offer square, triangle, and sine waves. Models 101, 102 and 104 are available with three power supply options: AC line power, dry cell battery, and rechargeable nickel cadmium batteries with built-in charger. Models 103 and 105 provide 30V p-p triangle, sine or square waves into a 600 ohm load. Models 103 and 105 are available in the AC power version only.

The 104 and 105 have the capability of having the dial electrically changed by application of an external voltage without physical movement of the dial. As such, they are truly general purpose F.M. modulators.

The wide frequency range of all five models makes them useful for low frequency applications such as servo and electro-mechanical systems, as well as audio or even video amplifier work. Complex oscilloscopes may be completely checked out for proper operation in the field or on the repair bench with this single, versatile, and portable instrument. The VCG is capable of sweep testing I.F. Strips, low frequency filters or F.M. of a servo. In addition, with proper inputs, it is possible to F.M. or sweep, a triangle, sine, or square wave. The very fast rise and fall times are ample for triggering high speed computer circuitry. Battery versions allow complete isolation from the power line and ground. This is particularly useful in any low level or wide band amplifier development work.

Models 101/102/103 have three outputs with independent amplitude controls: (1) 10V p-p max. square wave at 600 ohm output impedance; (2) 1V p-p square wave at 50 ohm output impedance, rise and fall time less than 5 nanoseconds; (3) Model 101 triangle wave 5V p-p max., Model 102 triangle wave 5V p-p or 2V rms sine wave, Model 103 triangle, sine,

or square waves 30V p-p max. into a 600 ohm load.

Models 104 and 105 have two outputs with independent amplitude controls: (1) 1V p-p square wave at 50 ohm output impedance; (2) Model 104: triangle wave 5V p-p max., sine wave at 2V rms, or square wave 10V p-p max. at 600 ohm output impedance; Model 105: triangle, sine or square wave 30V p-p max. into a 600 ohm load. The VCG input has an attenuator control which provides a minimum input impedance of 10K ohm. An input of 4.75 volts total will provide a 20:1 frequency range which is equivalent to full spread of the dial. The VCG input attenuator may be driven with any voltage up to 100V without damage to the instrument.

SECTION II
OPERATING INSTRUCTIONS

CONTROLS AND TERMINALS

1. Power Switch.

Applies line voltage or battery power to the instrument. In the case of the Models 101R, 102R and 104R, the rechargeable batteries are being charged when the instrument is ON and the power cord is plugged in. In the Model 102 this switch also selects whether the triangle or sine wave is applied to the lower left-hand terminals. In the Model 103 this switch selects triangle, sine, or square wave for the lower left-hand terminals. In the Models 104 and 105 this switch selects the X1 or X.3 frequency dial multiplier.

2. Frequency Range Switch.

Switches appropriate timing resistor and capacitor for proper frequency range.

3. Frequency Dial.

Adjusts input to amplifier for precise frequency control within range controlled by range switch.

4., 5., 6. Triangle, Sine, and Square Wave Amplitude Control and Output Terminals.

Model 101 and Model 102: The triangle or sine wave appearing at the terminals has a dynamic impedance of less than 5 ohms and is current-limited to drive 5 volts p-p triangle wave or 2 volts rms sine wave into a 600 ohm load. Amplitude is controlled by the pot directly adjacent to these terminals. At full amplitude the waveform is symmetrical with respect to ground. At minimum output there is a DC offset of approximately .1 volt. The ground terminals of all outputs are internally common to each other. For optimum waveform, use the ground terminal adjacent to the output being used. There is a slight interaction between the 600 ohm square wave output and this output. For optimum sine or triangle waveform at very high frequencies, keep the 600 ohm square wave amplitude control at minimum. Where very low amplitudes are needed, it is best to attenuate the output down to the desired level using a pair of external resistors and

then use the internal amplitude control for fine adjustment. This procedure allows more accurate control of amplitude and preserves very clean waveforms at low amplitudes.

Model 103 and Model 105: The dynamic output impedance for the triangle, sine or square wave is 50 ohm. The output is capable of driving a 600 ohm load 30 volts p-p. The output is current-limited to drive ± 100 milliamps into a short circuit. Amplitude is controlled by the pot directly adjacent to the terminals. At full amplitude, the waveform is symmetrical with respect to ground. At minimum output, the DC offset is less than 100 mv. For very low amplitudes it is recommended an external pair of resistors be used as described above.

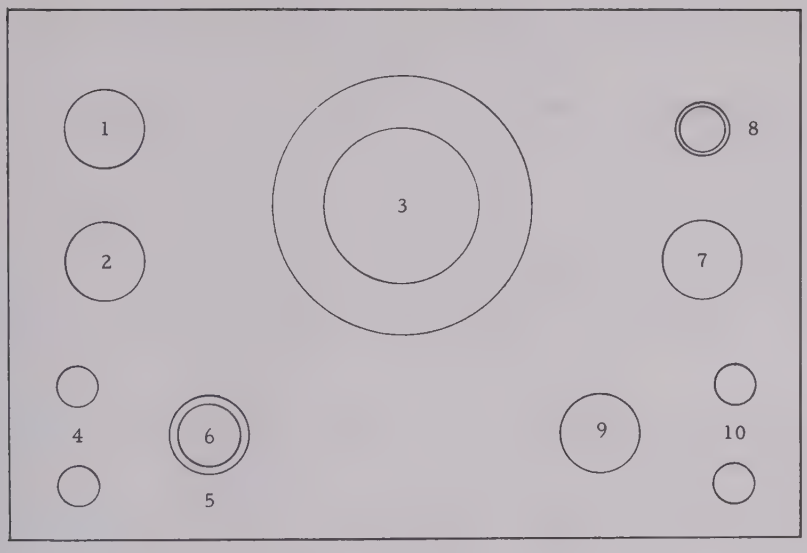
Model 104: The output impedance for the triangle, sine or square wave is 600 ohm. Max open circuit output is: triangle wave, 5 volts p-p; sine wave, 2 volts rms; and, square wave, 10 volts p-p ± 1% with a rise and fall time of less than 15 nanoseconds. The terminal is connected through a 560 ohm resistor to the arm of a 500 ohm pot. As the pot is varied, the actual output impedance will vary between 560 ohms and 685 ohms. The measured square wave rise time using a 30 Mc scope with a 10 pf probe will be about 20 nanoseconds. This is due to the capacitive loading of the probe at 600 ohms source impedance, and the rise time of the scope.

Model 104 and Model 105: The coaxial pot and switch adjacent to the terminals determine function and amplitude of this output.

7., 8. 50 Ohm Square Wave Amplitude Control and Output Connector.

The output voltage appearing at this connector is controlled by the pot directly adjacent. There is a slight interaction with the 600 ohm output. For optimum waveform, keep the 600 ohm output control at minimum when using the 50 ohm output. Due to the extremely fast rise and fall times (less than 5 nanoseconds), this output should be connected through a 50 ohm cable, terminated at the load by 50 ohms. The output connector is internally terminated by 50 ohms thereby eliminating the need to match it to the 50 ohm cable.

9., 10. Models 101 102 103. 600 ohm Square Wave Amplitude Control and Output Terminal: The amplitude of voltage appearing at the terminals is



Control	Model 101	Model 102	Model 103	Model 104	Model 105
1	Power OFF/ON	Power OFF/ON, Selector for triangle or sine at #4	Power OFF/ON Selector for triangle, sine or square at #4	Power OFF/ON, X1/X.3 dial multiplier	Power OFF/ON, X1/X.3 dial multiplier
2	Frequency Range	Frequency Range	Frequency Range	Frequency Range	Frequency Range
3	Frequency dial .8 to 10	Frequency dial .8 to 10	Frequency dial .8 to 10	Frequency dial .5 to 10	Frequency dial .5 to 10
4	Triangle 5Ω Output	Triangle or Sine 5Ω Output	Triangle, Sine or Square 30 volts p-p output	Triangle, Sine Square 600Ω Output	Triangle, Sine Square 30 volt p-p Output
5	Amplitude for #4 Output	Amplitude for #4 Output	Amplitude for #4 Output	Selector for triangle, sine, square at #4	Selector for triangle, sine square at #4
6				Amplitude for #4 Output	Amplitude for #4 Output
7	Amplitude for #8 Output	Amplitude for #8 Output	Amplitude for #8 Output	Amplitude for #8 Output	Amplitude for #8 Output
8	1 volt p-p Square Wave, 50Ω Output Fast Rise	1 volt p-p Square Wave, 50Ω Output Fast Rise	1 volt p-p Square Wave, 50Ω Output Fast Rise	1 volt p-p Square Wave, 50Ω Output Fast Rise	1 volt p-p Square Wave, 50Ω Output Fast Rise
9	Amplitude for #10 Output	Amplitude for #10 Output	Amplitude for #10 Output	VCG Input Attenuator	VCG Input Attenuator
10	Square Wave ± 5 volts ± 1% 600Ω Output	Square Wave ± 5 volts ± 1% 600Ω Output	Square Wave ± 5 volts ± 1% 600Ω Output	VCG Input	VCG Input

controlled by the pot immediately adjacent. At maximum output, the square wave will be plus and minus five volts, ± 1%. The rise and fall times generated at this point are less than 15 nanoseconds. The terminal is connected through a 560 ohm resistor to the arm of a 500 ohm pot. As the pot is varied, the actual output impedance will vary between 560 ohms and 685 ohms. The measured rise time using a 30 Mc scope with a 10 pf probe will be approximately twenty nanoseconds, due to the capacitive loading of the probe at 600 ohm impedance and the rise time off the scope.

Models 104/105. VCG Input Terminals and Input Attenuator: These terminals electrically operate in parallel with the frequency dial pot. The frequency dial pot generates a positive DC voltage. The higher the dial setting (max reading of 10), the larger the positive DC voltage generated by the dial pot. The lower the dial setting (min of .5), the lower the positive DC voltage generated by the frequency dial pot. The operator may electrically increase or decrease the frequency dial setting by applying an external voltage to terminals #10. In so doing, the operator may FM or sweep the frequency generated by application of a changing voltage to the VCG input terminals. The frequency of this modulation is limited only to where it is excessive in relation to the carrier frequencies being generated and carrier distortion results. Actually, the modulation frequency may exceed the carrier frequency, the result being many interesting oscilloscope patterns.

The VCG input terminals are calibrated such that when the control is set to minimum attenuation (CW most position), an external signal of 1 volt will change the frequency the equivalent of two major dial divisions. Thus, 4.75 volts will change the frequency the full dial spread of .5 to 10. The relationship between the externally applied voltage and the frequency is linear within ± 1%.

The terminals and the dial operate in conjunction such that if the externally applied modulation voltage goes from zero to some positive voltage, the dial should be set at the minimum frequency desired with the modulation voltage electrically pulling the dial up. In turn, if the modulation goes from zero to negative, the dial should be set at the maximum desired

frequency. If the modulation voltage is symmetrical about ground, the dial should be set at the mid frequency.

The X1/X.3 dial multiplier is incorporated to eliminate the bad overlap problem which would exist with range steps of 10:1 and a sweep frequency capability of 20:1 maximum.

The quickest way to demonstrate the operation of the VCG input is to connect it to a Tektronix 530 Series or equivalent oscilloscope connecting the sawtooth output of the scope to the VCG input terminals. Set the dial at .5 on a convenient range such as X1K. Back off on the VCG input attenuator to about 8 o'clock. With the scope set a 1 millisecond per centimeter, a 20:1 sweep frequency pattern will be displayed on the scope if the VCG attenuator is properly set. If the attenuator is set too low (CCW), less that 20:1 sweep will result. If the attenuator is set too high, maximum dial frequency will occur before the end of the sweep and the remaining sweep will be at the same maximum frequency. This sweep frequency signal may be applied to a filter, etc., and the output of the filter applied to the scope to automatically display the characteristics of the filter. One caution: The higher the sweep speed setting of the scope, the greater the rate of change of frequency. The VCG is not affected by rapidly changing frequencies, however, high Q filters, etc., are sensitive to change in frequency and if the sweep speed is set too high, the filter will ring resulting in a distorted presentation on the scope.

GENERAL

All outputs with their independent controls may be used simultaneously. Any output terminal may be shorted to ground without effect on the other terminals. The interaction of the 600 ohm output on the other outputs is only slightly noticeable from approximately 100 Kc up in frequency. The signal grounds for all three outputs are common to each other, but are isolated from the case, which is connected to the third pin on the power cord.

MODELS 101B, 102B and 104B

To preserve battery life, it is recommended that the unit be turned on

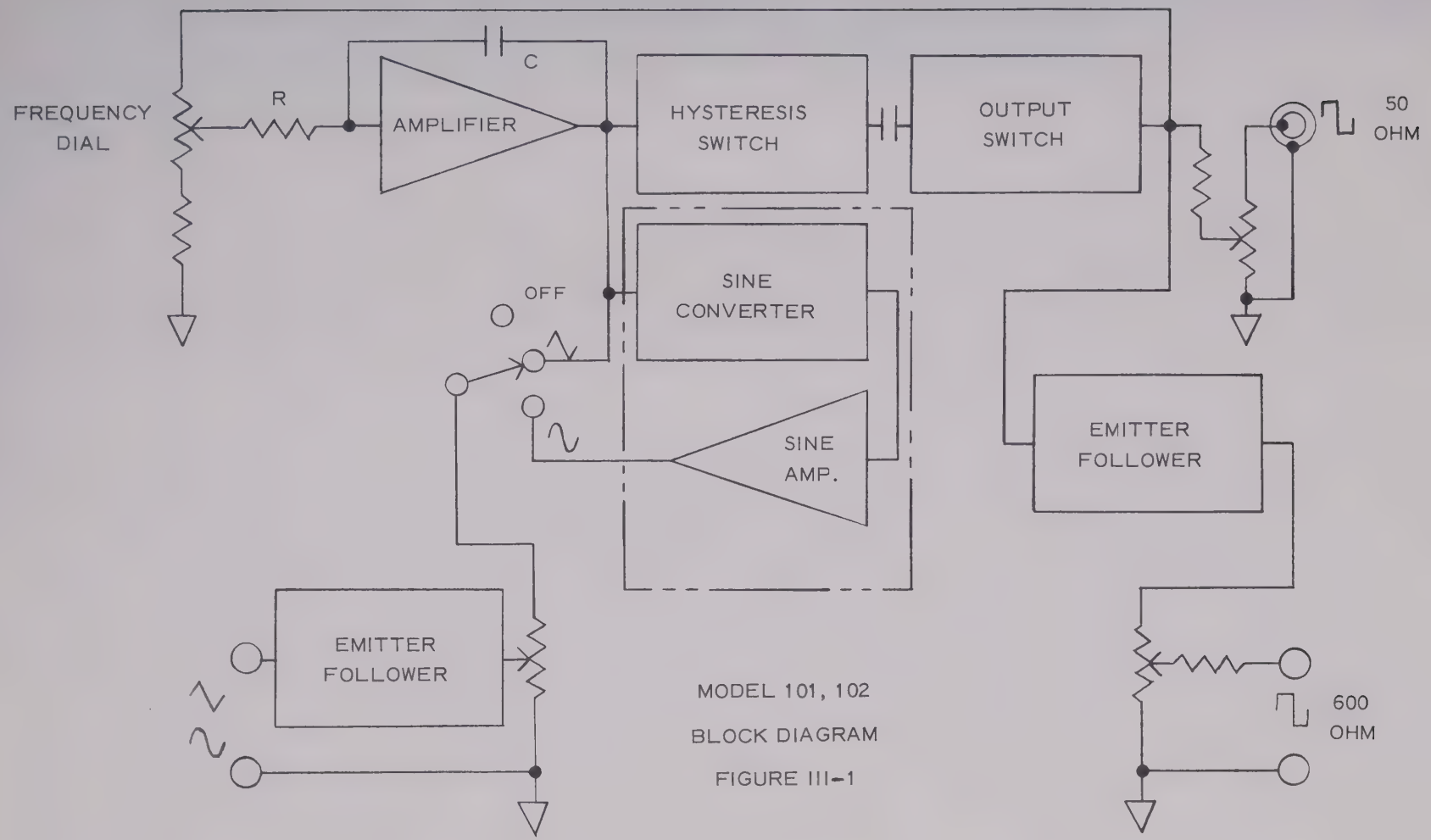
only when in actual use. Due to the fact that total power consumption (approximately 1.5 watts) is extremely small, internal heating is negligible. Initial drift is stabilized within the first few seconds of operation.

MODELS 101AC, 102AC, 103, 104AC and 105

Total power consumption is less than 10 watts, thus warm-up time is again negligible.

MODEL 101R, 102R and 104R

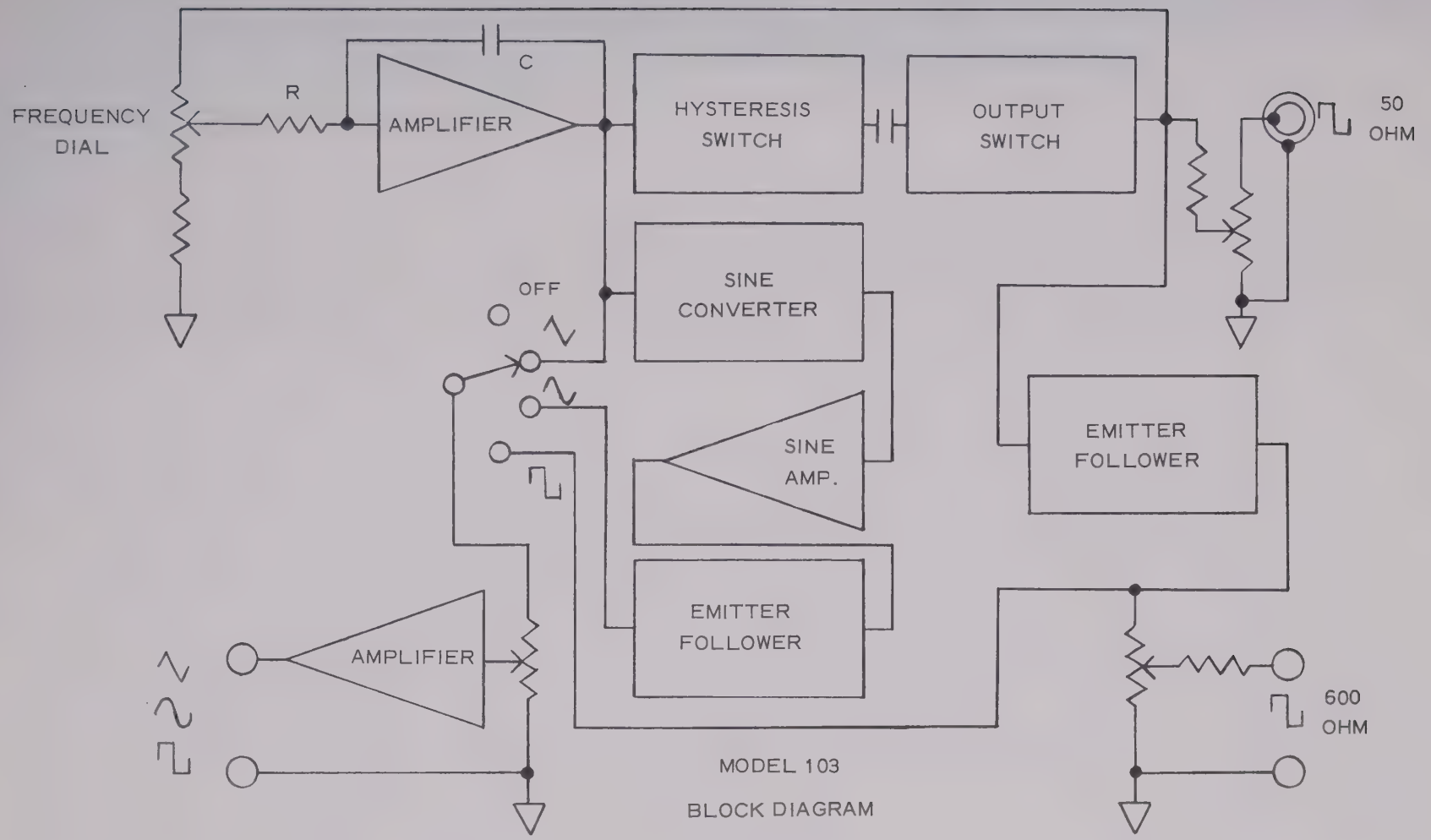
These units may be operated plugged into AC power or not. When plugged in, batteries are being charged. When not plugged in, the batteries are being discharged. These units will run continuously for eight hours on batteries if the rechargeable cells have been completely charged. The built-in charger has an internal adjustment for setting the charge current. Unless otherwise specified, units are shipped from the factory with the charge current set for 30 ma. At this rate of charge, the unit can be operated continuously plugged into the AC, maintaining the batteries at full charge all the time without damage to the batteries. However, the charge time from complete discharge to full charge is about 40 hours. The charger may be re-adjusted for a charge current of 100 ma, enabling a complete charge to be accomplished in 14 hours. With this setting of charge current, it is not recommended that the unit be operated continuously for extended periods when plugged in or the batteries will be overcharged and their ultimate life will be shortened. Where it is desired to operate a full working day on batteries, the charge current should be set at 100 ma, the unit operated 8 hours on batteries and operated 14 to 16 hours plugged in (charging).



MODEL 101, 102

BLOCK DIAGRAM

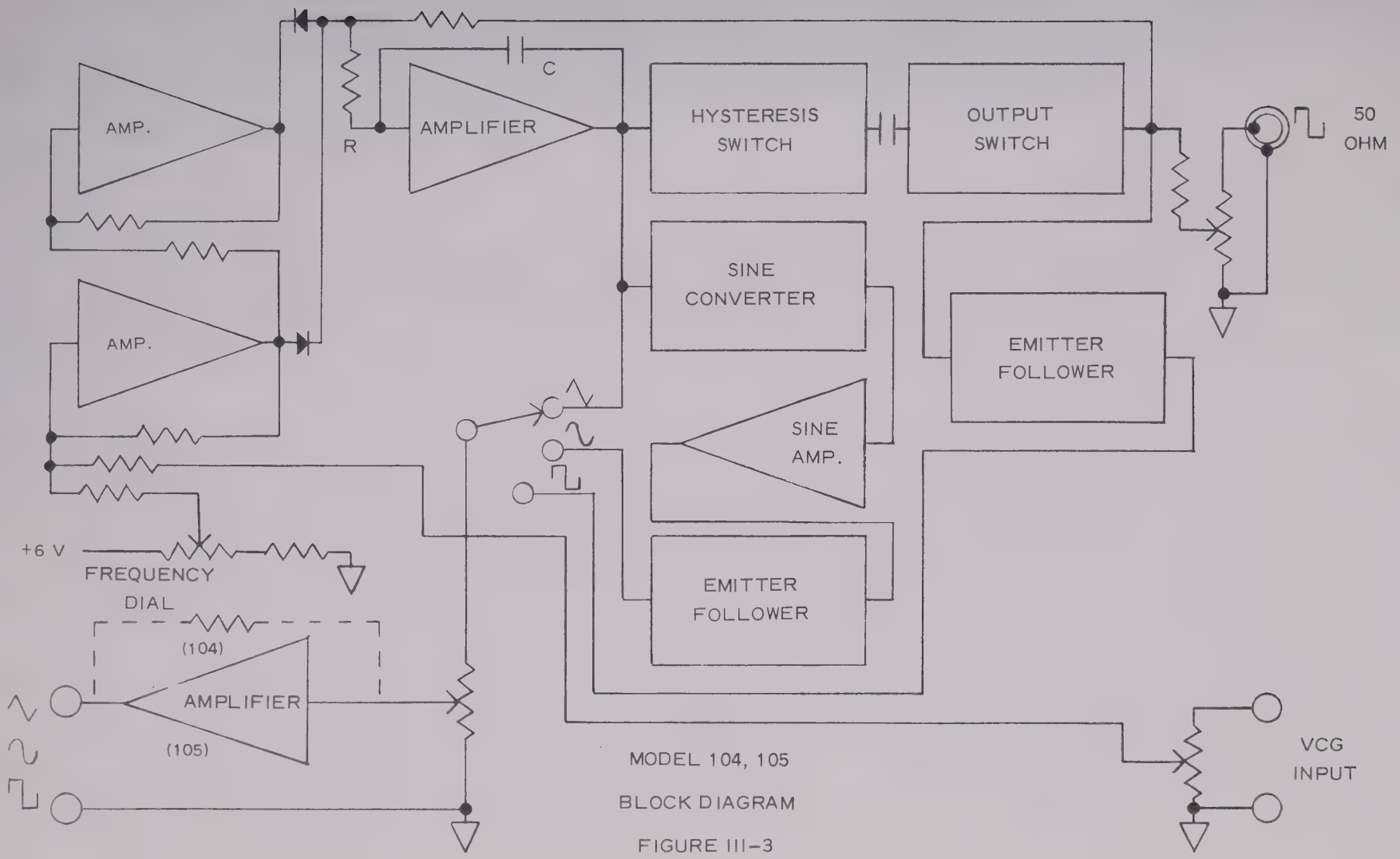
FIGURE III-1



MODEL 103

BLOCK DIAGRAM

FIGURE III-2



MODEL 104, 105

BLOCK DIAGRAM

FIGURE III-3

SECTION III
THEORY OF OPERATION

GENERAL THEORY OF OSCILLATION

Figure III-1 is a block diagram of the Models 101 and 102 Function Generators. Figure III-2 is a block diagram of the Model 103 Function Generator. The Model 101 includes the complete oscillating circuitry for generating both the triangle and square wave. The Model 102 has an additional printed circuit board which shapes the triangle wave into a sine wave and amplifies the reduced signal to the nominal output. The Model 103 is essentially a Model 102 with the addition of a high voltage power amplifier for providing 30 v p-p output into 600 ohms. Thus, all three models are essentially the same basic generator.

Figure III-3 is a block diagram of the Models 104 and 105 which are VCG versions of the Models 102 and 103. Figure III-3 is the same as Figure III-2 except that the frequency dial pot has been replaced by a clamping circuit composed of two diodes and two cascaded operational amplifiers.

The generators use a completely transistorized, wideband, chopper-stabilized, amplifier to obtain the wide frequency range. The amplifier is hooked up as an integrator. A constant voltage appearing at the arm of the frequency dial pot causes a constant current to flow through R. Due to the high gain of the amplifier, the input to the amplifier remains essentially at ground potential. The input impedance of the amplifier is extremely high; as a result, essentially all the current flows through the integrating capacitor C. This causes a linear change in the voltage across C and, thus, produces the linear triangle output voltage. The output of the amplifier is fed into a hysteresis switch, a four-transistor flip flop (to be described later) biased so that it remains in one state until the input voltage reaches a certain predetermined level. The output of the hysteresis switch then changes state. This output is capacitively coupled to the output switch, another four-transistor flip flop. The output of the output switch is, thus, a square wave switching between approximately plus and minus five volts. This output is then fed into the frequency dial pot. A

positive voltage appearing on the frequency dial pot causes a negative-going voltage on the output of the amplifier (the amplifier is phased to invert the input). This negative-going voltage causes the hysteresis switch to switch to a positive output. This negative to positive switching causes the output switch to switch from positive to negative, thus, reversing the input to the amplifier and, hence, the slope of the output voltage to the amplifier. In this manner the unit oscillates, simultaneously producing a triangle wave and a square wave.

Frequency of oscillation is determined by the R and C in the circuit and the position of the frequency dial pot. A large R causes less current to flow, resulting in reduced rate of change of voltage across C and, thus, lower frequency. A large C with given current causes reduced rate of voltage change across C and, thus, lower frequency. As the arm of the frequency dial pot is moved closer to ground, less voltage is present on the arm and, thus, less current flows through R, again resulting in lower frequency of oscillation.

The Models 104 and 105 Voltage Controlled Generators utilize a clamping circuit to control the amplitude of the square wave rather than a simple pot. Figure III-3 shows the output switch feeding through a resistor to the clamping diodes and, in turn, to the timing resistor R. The two cascaded operational amplifiers control the bias voltages applied to the two clamping diodes. The second amplifier has a net gain of exactly -1. As the input voltage applied to the first amplifier is increased from zero to a positive voltage, the output of the first amplifier will be increased to a negative voltage and the output of the second amplifier increased to a positive voltage. Thus, the clamping voltages are spread from ground and the amplitude of the square wave appearing at the junction of the two diodes will increase. The effect is the same as raising the arm of the dial pot on the Model 103. The two amplifiers provide very stiff low impedance bias sources for the two diodes. They are driven from the frequency dial pot which is now a DC control and the external VCG input. The dial operates in parallel with the external input.

The amplitude of the triangle wave would vary if the firing points of the hysteresis switch varied. This firing point, however, is held very stable

over the entire frequency range of the instrument, assuming the power supply voltages remain constant. Should the power supply voltages vary, the amplitude of the square wave fed into the frequency dial pot would vary. To compensate for this, the hysteresis switch firing point is made to vary in direct proportion, thus, maintaining constant frequency. For a $\pm$ 20% change in supply voltage the frequency of oscillation varies about $\pm$ 1%. The supply voltage is held to $\pm$ 1% by the regulator. The R and C used is controlled by the frequency range switch. To cover the entire 8 decade ranges, 3 resistors (4.64K, 46.4K and 464K) and 4 capacitors (100 pfd, .001 mfd, .1 mfd and 10 mfd) are used. The frequency dial pot is a 1K pot. The 4.64K resistor does load this pot slightly. To compensate for this loading, the 4.64K resistor is switched from the arm of the pot to ground when the 46.4K and the 464K resistors are used. In this manner the frequency dial calibration remains accurate for all ranges. The triangle wave output of the amplifier (or the sine wave) is fed through the triangle (sine) amplitude control to a super-emitter follower to the output terminal. The current limited super-emitter follower is used to provide low dynamic impedance. The square wave output is fed through a push-pull emitter follower to the 600 ohm amplitude control and to the output terminal.

FOUR-TRANSISTOR SWITCH

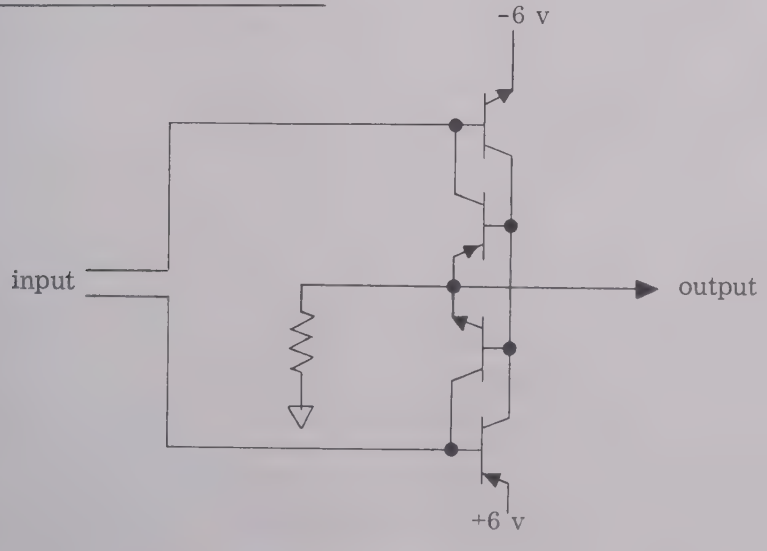


FIGURE III-4

Figure III-4 is a simplified schematic of the four-transistor switch* used as the hysteresis switch and the output switch. The switch consists of two pairs of transistors, each pair using one NPN and one PNP transistor. The pairs are hooked up so that either the top pair or bottom pair are on, in saturation, the opposing pair being off. Each pair is wired so that the collector of the NPN supplies base current to the PNP, and the PNP collector supplies base current to the NPN. The four-transistor switch is connected between the plus six volt and minus six volt supplies. The output of the switch is the common emitters of the center NPN and PNP transistors. This common emitter point switches to one supply voltage or the other, depending upon which pair is on. The bases and emitters of the center two transistors are tied together. Since one is a PNP and the other an NPN, they cannot be on at the same time. This unique configuration provides extremely fast switching speeds with essentially all the power supply current going through the load connected to the common emitter. The hysteresis switch differs from the output switch in that the outside emitters are not tied directly to the power supplies, but rather tied to a resistance network. The bases of the outside transistors are biased with diodes and a resistor network. These networks compensate the hysteresis switch firing point with changing supply voltages so that the frequency of oscillation remains constant.

Extreme care should be used to avoid shorting this switch with tools, etc., when the power is on, since any short may cause a transistor to be directly shorted across the power supplies.

AMPLIFIER

Figure III-5 is a simplified schematic of the amplifier. The wideband, chopper stabilized, DC amplifier consists of two amplifiers. The top amplifier is a wideband DC amplifier with an open loop gain of approximately 2000. The bottom amplifier is a carrier amplifier to provide additional DC gain and DC stability. The carrier amplifier is necessary to provide the high DC input impedance for the lowest frequency range

*Patent applied for.

where the R is 464K or 952K.

The input transistor, Q21, of the wideband amplifier is an emitter follower. This drives another emitter follower, Q23. The collector of Q21 is bootstrapped to increase the input impedance. Q23 drives the long-tailed pair, Q25 and Q26, the base of Q26 being grounded. Q26 drives Q32. Most of the voltage gain within the amplifier is accomplished by Q32. Q31 provides a low impedance emitter bias for Q32. The output of Q32 drives the output emitter follower, Q33. The over-all amplifier has a bandwidth of approximately 20 megacycles. The additional components shown on the schematic are roll-off networks and filters provided to avoid oscillation at very high frequencies. The DC input to the base of Q21 is provided by the output of the carrier amplifier and R66 which is included so that the amplifier may be adjusted to exactly zero volts DC out for zero volts DC in.

The carrier amplifier is very similar in configuration to the wideband amplifier. The input signal is applied to both amplifiers. The carrier amplifier has high DC negative feedback from the collector of Q30 to the base of Q22, provided by the two resistors and filter capacitor. Frequencies above about 50 cps feed through the coupling capacitor to the base of Q21. Frequencies below about 50 cps are fed through the filtering network to the solid state chopper, Q19. The base of Q19 is driven by the chopper oscillator at a frequency of approximately 1.5 KC. When the base is positive, Q19 is on and the voltage drop between the emitter and collector is approximately 2 millivolts. When the base is negative, Q19 is turned off and the input signal is applied through the coupling capacitor to the base of Q22. Q22, 24, 27, 28, 29 and 30 operate in a similar manner to the wideband amplifier. A small input signal produces a small square wave signal at 1.5 KC frequency. This signal is amplified, producing a large square wave at the collector of Q30. The collector of Q30 is fed through the resistor and capacitor to the emitter of Q34. Q34 is hooked up as a solid state chopper which acts similarly to Q19, except that being PNP rather than NPN, the output is clamped to ground when the chopper oscillator voltage is negative. The resulting signal on the emitter of Q34 is a square wave, one side of which is clamped to ground. If the input signal is positive, the square wave appearing on the emitter of Q34 will be positive, and if the

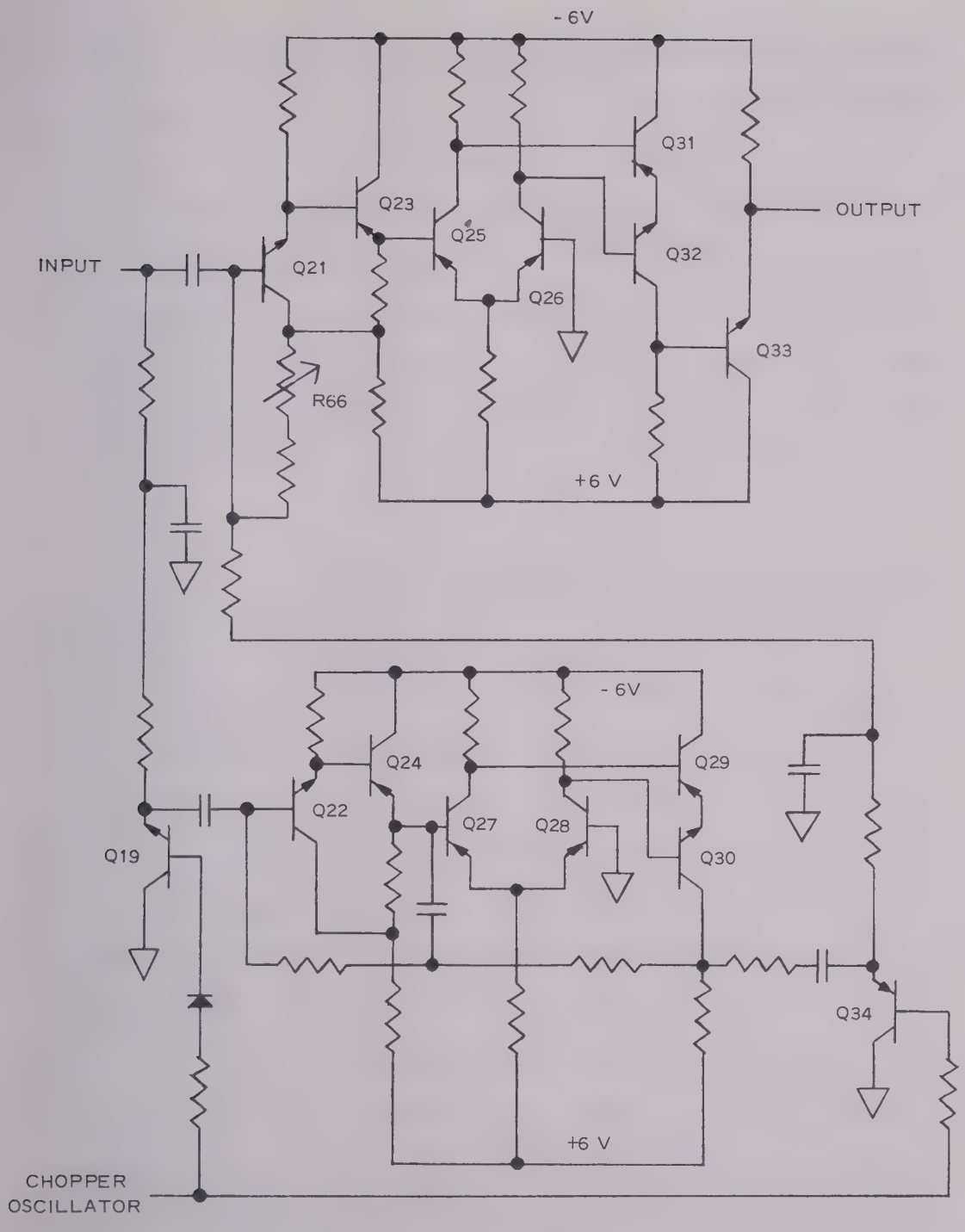
signal is negative, the square wave will be negative. The amplifier, Q22 - Q30, inverts the signal. The use of one NPN and one PNP chopper also inverts the signal, the net result is, thus, positive output for positive input. The square wave appearing on the emitter of Q34 is filtered with a cut-off frequency, approximately 50 cycles, and fed to the base of Q21. At very low frequencies, both amplifiers have gain. The resulting open loop gain is over 100 db.

CHOPPER OSCILLATOR

The chopper oscillator is a standard multivibrator that has been modified so that the output is a relatively clean square wave and so that oscillations always start, even with slow application of power supply voltages. Diodes CR7 and CR8 allow the voltage at the collectors of Q16 and Q20 to return immediately to -6 volts when the transistors turn off. This provides a good square wave output. Resistors R50 and R53 are returned to their own collectors, through CR7 and CR8, rather than to -6 volts. Should both transistors turn on, insufficient base current is available for them to stay on; one of the units will thus turn off and oscillation will commence.

FAIL-SAFE CIRCUITRY

It is possible for the oscillator described herein to lock up and not oscillate. This happens when the hysteresis switch and the output switch are not both on, in opposite phase. To avoid this possibility, a fail-safe network, consisting of R35, R36, R37, R41, R43, R48, R102, C13, C16, C37, CR5 and CR6, is provided. If the hysteresis switch and the output switch are not both on, in opposite phase, the junction of R41 and R48 will not be at ground. If the voltage at the junction of R41 and R48 is positive, CR5 will conduct, supplying a square wave of phase opposite to the normal signal to the base of Q22, forcing the emitter of Q34 negative, forcing the output of the amplifier positive, forcing the output of the hysteresis switch negative. Negative voltage appearing at the junction of R41 and R48, CR6 conducts and the output of the amplifier is reversed, the output of the



AMPLIFIER

SIMPLIFIED SCHEMATIC

FIGURE III–5

hysteresis switch switches to negative, switching the output switch to positive, and oscillation commences.

VOLTAGE REGULATOR

The voltage regulator is of conventional design. Q3 and Q6 being pass transistors, Q4 and Q5 voltage amplifiers, Q1 and Q2 constant current drives for the bases of the pass transistors. The negative supply is referenced closely to the Zener voltage generated by CR3. The positive supply is referenced closely to CR12. Adjustment of R8 controls -6 volts directly and +6 volts slightly. Adjustment of R11 controls +6 volts directly and -6 volts slightly. R5 and R6 reduce the power dissipation in the two pass transistors.

SINE SHAPING CIRCUIT AND AMPLIFIER

The Models 102, 103, 104 and 105 incorporate a printed circuit board for converting the triangle wave to a sine wave. For circuit details and waveforms refer to the sine converter schematic located in Section VI. The triangle wave to be shaped is applied to a diode limiting circuit comprised of diodes CR501 through CR506 and resistors R506, R509 and R522. The diodes are biased by transistors Q502, 3, 4, 6, 7 & 8. Diode bias voltages are determined by the base voltages of the transistors. PNP and NPN transistors symmetrical about ground are used so that emitter regions are connected to similar regions of the limiting diodes.

The temperature characteristics of the transistor base-emitter junctions are equal to but opposite in polarity to the respective diodes. The resulting over-all voltage drop from the base of the transistor to the diode junction point remains constant with changes in temperature.

Voltages at which the diodes conduct are determined by adjustments R523, 4, 5. As the input voltage applied through R506 increases positively from ground, diodes CR502, CR503 and finally CR501 will conduct. As these conduct in turn, the slope of the output voltage gradually decreases. Discontinuity in waveform is minimized since the diodes are operated at low levels and the diode characteristic curvature smooths the waveform. The resultant waveform at the junction of R506 and R537 is a clean sine

wave except for cusps at maximum and minimum points caused by the dynamic impedance of diodes CR501 and CR505. To eliminate these cusps the total transistor collector current (inverse of diode current) is drawn through R501 and R502. This signal is amplified and inverted by Q505 and Q501. The resultant signal appearing at these collectors is the cusp signal 180 degrees out of phase. This wave is summed through R520 along with the distorted sine wave through R537, to present an accurate sinusoidal wave at the input of the amplifier. Waveforms are shown on the schematic.

The entire circuit is completely symmetrical about ground. Capacitors C501 through C506 are provided to maintain fixed base voltages at high frequencies. The resultant clean sine wave appearing at the junction of R537 and R520 is approximately 2 v p-p. This voltage is amplified by Q509, 10, 11, 12 to approximately 5.6 v p-p.

The amplifier is a push-pull potentiometric amplifier. Feedback is accomplished through R529. The gain of the amplifier is principally dependent upon the ratio of R529 to R531. R527 and R536 are selected for DC balance and proper over-all voltage output.

Optimum sine wave fidelity is provided by the 1% resistors used in the sine shaping circuit. Typical distortion is less than .5%.

MODEL 103/105 POWER AMPLIFIER

Models 103 and 105 incorporate an operational amplifier using all silicon transistors to amplify either the triangle, sine, or square wave to 30 v p-p. Configuration of this amplifier is very similar to that of the basic amplifier described previously. For details refer to the schematic located in Section VI. The gain of the amplifier is determined by the ratio of R607 (and R608) to R601. Q601 and Q602 operate as a long-tail pair. The output of Q602 is in turn amplified by Q603. Q604 and Q605 operate as push-pull emitter followers. CR601 and CR602 provide a bias voltage to offset the base-emitter voltages of Q604 and Q605. The total drop of the two diodes is slightly less than the total drop of the two base-emitter junctions. CR601 and CR602 are germanium diodes for low forward drop. R612 and R613 are current-limiting resistors which limit the maximum output current in the case of a short circuit to $\pm$ 100 mils. The amplifier

is so designed that if it is necessary to drive an impedance less than 600 ohms, the input to the amplifier may be set, by adjusting R20, in order that a clean waveform may be developed across loads as low as 10 ohms. As a result, the amplifier may be used as a voltage amplifier supplying up to 30 v p-p across a 600 ohm load or as a current amplifier driving very low impedance loads. R113, R114 and R115 are trimmed at the factory so that all three waveforms come out at the same maximum 30 v p-p into 600 ohms. C603 is a trimming capacitor for optimum frequency response. This amplifier is mounted, along with its power supply, in the power supply section of the generator.

MODEL 104/105 VCG AMPLIFIER BOARD

The VCG amplifier board contains two cascaded operational amplifiers essentially identical in circuitry. The first amplifier has a net gain of approximately -2. The second amplifier has a net gain of exactly -1. The amplifiers are straight forward with a long tailed pair driving another long tailed pair driving an output emitter follower. Matched transistors are used for the input long tailed pairs for minimum DC offset.

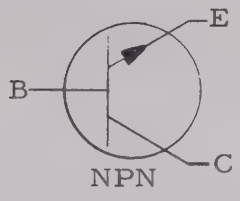
The clamping diodes CR802 and CR804 operate open circuit without feedback around them. To compensate for this, a matched diode is placed within the feedback loop. CR801 is used to compensate for CR802 and, in turn, CR805 compensates for CR804. Feedback for the first amplifier is taken from the cathode CR801. Thus, CR801 is matched to CR802. In addition, R816 and R817 are provided so that the current through CR801 always matches the current through CR802 when it is conducting. In this way, the clipping voltage at the cathode of CR802 is always made to agree with the sum of the input voltages fed through R801 and R802.

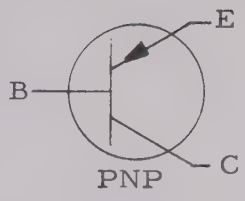
The second amplifier operates exactly as the first and is designed to provide the equal and opposite clamping voltage for the square wave. R820 or R824 is selected for this symmetry. The output emitter follower of the second output amplifier Q810 is a PNP rather than an NPN (Q805) since the clamping diode CR804 is reversed. Again CR805 is matched to CR804 and functions as previously described. In operation, a 5.2 volt

square wave appearing on the yellow elco pins is fed through R832 to the clamping diodes. The square wave appearing at the junction of the diodes will be symmetrical about ground and the amplitude will be controlled by the input voltages to R801 and R802. This clamped square wave is fed to the integrating resistor R shown on the block diagram. The entire circuitry is designed to have an operating range from $\pm$ 0.15 volts (dial setting of .5), to $\pm$ 3.0 volts (dial setting of 10). Overdriving the input to R802 will not cause any damage but will cause excessive distortion in the output waveforms. The Models 104 and 105 will operate within specifications only over the frequency range covered by the dial graduations.

TRANSISTOR OUTLINE DRAWING

E = Emitter
B = Base
C = Collector





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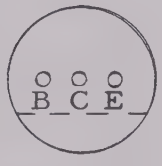
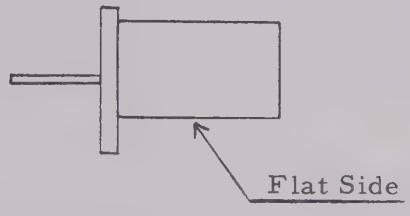
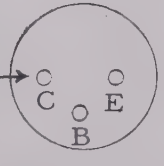


Bottom View



EPOXY

Sometimes Black around base of "C" lead.



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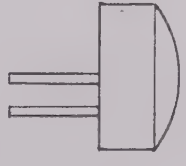
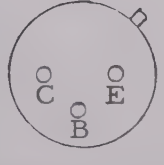


Small and Large

METAL CAN



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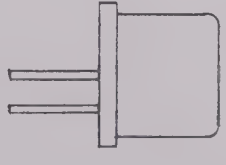

TO5 and TO18

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SECTION IV
MAINTENANCE

BATTERY REPLACEMENT

Batteries need replacing or, in the case of the Model 101R, 102R, and 104R, need recharging, when the maximum output of the 600 ohm square wave drops below 10 volts. To replace the batteries, first turn the power off and remove the cover. Slide the battery plate assembly up, about half way out of the instrument. The battery assembly is held relatively firmly in place, but does slide up. Remove the three battery leads connected by Elco pins, using care not to short the batteries. Remove the battery assembly from the instrument and replace batteries.

In the Model 101B, 102B, and 104B, industrial type flashlight batteries are recommended for longer life. In the Model 101R, 102R, and 104R, it is necessary to have batteries in place for proper operation.

REPLACEMENT OF FUSES

Should the unit fail to operate, first check the batteries and the fuses. Turn the power off before attempting to replace fuses to avoid possible shorting of batteries. In the case of line powered units unplug the instrument from the line. The 1/4 amp fuses are 8AG instrument fuses. 8AG UL are not satisfactory substitutes. For the 3/8 amp fuses, the reverse is true. The proper fuse is 8AG UL.

DISASSEMBLY

Should detailed work on the instrument be required, it is recommended that the unit first be disassembled. After removing the cover, remove the batteries and then the two slotted bars on the left which hold the boards in place. Remove the power supply leads going to the fuses. Next, pivot the plate mounting the power supply to the rear, clearing the switch shaft, and out of the chassis. The main printed circuit board (including sine board) may be removed by removing the 13 wires connected by Elco pins. The Elco pins are color-coded to match wires for proper re-assembly.

For removal of the main board, slide it to the left, pivot to the rear and out. The main board may now be serviced independently from the rest of the instrument, as described later.

To gain access to the regulator printed circuit board immediately behind the front panel, first unsolder the 470 ohm resistor connected to the frequency dial pot on 101, 102, and 103 only. Next, remove the three nuts which hold the unit in place. The printed circuit board may now be folded away from the sub-panel and sufficient access gained for replacement of any component on the board. It is not recommended that this board be completely removed for maintenance purposes. It is also not recommended that the sub-panel be removed for maintenance purposes.

ADJUSTMENTS

In the Model 101, etc., four adjustments are available for normal maintenance purposes. Before making any adjustments, check battery voltage for at least plus and minus 7.2 volts. The two trim pots mounted on the regulator printed circuit board control the two supply voltages. The left-hand trim pot is R8 and controls the -6 v supply. The right-hand trim pot is R11 and controls the +6 v supply. There is some interaction between these two adjustments, so that it may be necessary to go back and forth several times to obtain the proper setting. To adjust these pots, turn the unit on and set to a frequency of approximately .05 cps. Set the 600 ohm output control for maximum and measure the output with an accurate voltmeter (better than 1%). Adjust R8 and R11 so that the total square wave output is exactly 10 v and the +6 v and -6 v supplies are equal. With the two 6 v supplies set exactly equal, the 600 ohm square wave output will have a slight DC offset from ground. A typical set of readings when the adjustments are properly made are: +5.02 v, -4.98 v, +6.17 v and -6.17 v.

R32 is the adjustment trim pot for the DC balance of the triangle wave and is located at the top of the main printed circuit board. Set the triangle wave output control for maximum and adjust the R32 for balance with respect to ground. This should be done after R8 and R11 are properly adjusted. In Models 102 103 104 105, R32 may be retrimmed for maximum

sine wave distortion. Description of this procedure is included in the paragraph on sine wave adjustments.

The only frequency calibration adjustment normally required is C5, which is located on the regulator printed circuit board near the top of the instrument. This controls dial accuracy of the highest frequency range only. In making this adjustment, make sure the entire dial is within calibration. It is normal for the dial to read high at 1 megacycle and read low at 500 KC to 700 KC. Adjust C5 so that both these points come within specification.

All other frequency calibrations are considered to be fixed. However, it might be necessary to make adjustments due to changing transistors Q12 through Q15 or changing the frequency dial pot, R16. Should adjustment be required, it is recommended that this be accomplished by the factory. This not being practical, the following procedure is given: R56 and R57 directly control dial accuracy at the bottom end of the dial (reading of 1) and have a minor effect on higher dial settings. Resistors R21 and R22 directly control dial accuracy at the top end of the dial and affect the entire dial as a percentage of reading, not dial divisions. The procedure for bringing the dial into calibration is to pick the X100 range and simultaneously juggle the four resistors mentioned to bring the entire dial into calibration. In the event that R16 has been replaced, it is sometimes found necessary to add a resistor between the arm and the low side of the dial pot to bring the entire dial within calibration. Typical values for this resistor are 4.7K to 10K. The resistor should be mounted with short leads right on the pot.

Should a particular range of frequencies or several ranges of frequencies, other than the top range, be definitely out of calibration, the appropriate R or C should be replaced.

The Model 102, 103, 104, and 105 have additional adjustments for sine wave distortion. Equipment required for proper adjustment of the sine wave is a Hewlett-Packard type 330 distortion analyzer, or equivalent, a good general purpose scope, preferably dual trace, and a voltmeter with at least 1% accuracy.

Before commencing the adjustments for sine wave distortion, the power

supply must be properly set. Adjust R8 (-6v) and R11 (+6v) as described previously. When sine wave distortion adjustments described below are completed, slight improvement in sine wave distortion may be accomplished by minor touch up of R8, R11 and R32. However, make sure that this touch up has not put the 10 volt square wave amplitude out of the ± 1% spec.

Set the generator range switch at X100 and the frequency dial to 10. Set function switch to SINE and sine amplitude to maximum on the 102/104 and 1/2 on the 103/105. Connect the sine wave output to the distortion analyzer input and to the second channel of the scope, if dual channel is used. Connect the square wave output to the external trigger input of the scope and trigger the scope from this external trigger. Connect the first channel input of the scope to the output of the distortion analyzer. Tune the distortion analyzer to approximately 1KC and operate the distortion analyzer in accordance with the standard operating procedures. Note that it will be necessary to go back and reset the SET LEVEL in making the final distortion measurement.

With the distortion analyzer properly tuned and balanced and set to Distortion, adjust R523, R524 and R525 for minimum distortion. Adjust R32 on the main printed circuit board for minimum even harmonic distortion. For a particular setting of R523 there is an optimum for R524 and R525. When this is reached, note the distortion and then give R523 one turn, either CW or CCW and readjust R524 and 525 for minimum distortion. Note whether this distortion is less than or greater than the previous readings. After several tries, you will arrive at the optimum setting for R523 and also R524 and R525. The resultant distortion should be .5% or less.

Set the frequency dial of the 102/103 to .8 (104/105 to .5), tune the distortion analyzer to approximately 80 (50) cycles, and adjust R66 on the main printed circuit board for minimum distortion. Do not readjust any other controls at this time.

During this entire procedure, monitor the sine wave output of the Generator and the residual output of the distortion analyzer on the scope. Use the meter on the distortion analyzer in determining optimum adjust-

ment, but note the residual output on the scope. Each control will affect a particular portion of the sine wave. When all adjustments have been properly made, the residual output observed on the scope will consist primarily of eleventh harmonic. Second harmonic distortion at 1KC should be practically nonexistent.

The Model 103/105 contains one additional adjustment: C603, which adjusts the frequency response of the output amplifier for optimum frequency response. In making this adjustment, have the unit completely disassembled with the cover removed. Set the generator for maximum (30 v) output and connect a 600 ohm load. Set the generator for 100 KC output. Adjust C603 for maximum rise time without overshoot. Check the rise time and make certain it is within the 100 nanosecond specification. It may be necessary to have a very slight over-shoot (1%) in order to obtain specified rise time. Fall time (plus to minus transition) should now fall well within 100 nanoseconds.

The Model 104 and 105 VCG amplifier board contains no adjustments although, if a component is changed, it may become necessary to re-match or select for operation some of the associated components.

CORRECTION FOR FAILURE TO OSCILLATE

1. Check for proper battery voltage or AC supply voltage.
2. Check fuses.
3. Check for approximately plus 6.2 volts on the red wire going to the main printed circuit board and approximately minus 6.2 volts on the brown wire going to the main printed circuit board. Should this not be the case, the regulator may be independently checked by disconnecting these leads from the main printed circuit board and connecting a load of 62 ohms from each to ground (see service kit). If proper operation of the regulator cannot be obtained, correct the fault in the regulator, using the Disassembly instructions. Should the regulator function properly when connected to a dummy load, but not when connected to the main board, remove the main board as described in Disassembly and trace out the short.

SERVICE KIT

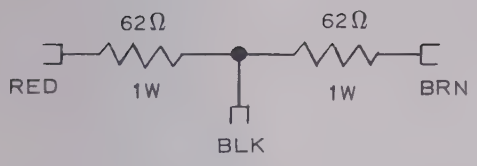
Figure IV-1 shows all of the test fixtures which make up the service kit Part No. SK-102. This kit contains all of the test fixtures necessary for complete checkout or repair of the main board and sine board with the unit disassembled, accessible for easy maintenance. The service kit is available complete from Wavetek, or in emergency may be easily fabricated locally.

Fixture 1 is a dummy load for the power supply regulator mounted on the sub panel. Fixture 2 is an extension cable for connecting the regulator to the main board when the main board is out of the chassis. Fixture 3 is a resistive input-feedback network for operating the integrator as an amplifier when the unit fails to oscillate. Fixture 4 is the integrator network for operating the unit as an oscillator over the frequency range of 6.5 cps to 10 kc. Fixture 5 is a dummy load for the output switch and the push-pull emitter follower. Fixture 6 is a clip lead for connecting the output switch to the integrator. Fixture 7 is the integrator network for operating the unit as an oscillator at 100 kc and 1 mc. Fixture 8 is a dummy load for the sine board amplifier.

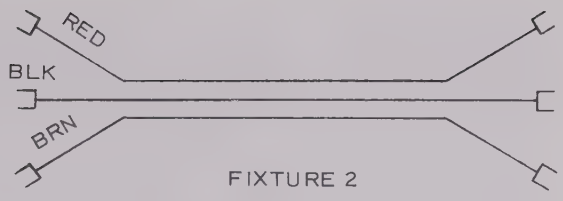
MAIN BOARD CHECK-OUT

In the event that the unit fails to oscillate, or oscillates with poor waveform, and it has been determined that the supply voltages are correct, the main board may be completely checked out independent of the rest of the unit. Materials required are the service kit SK-102 (or equivalent), a good general purpose DC oscilloscope, and an oscillator.

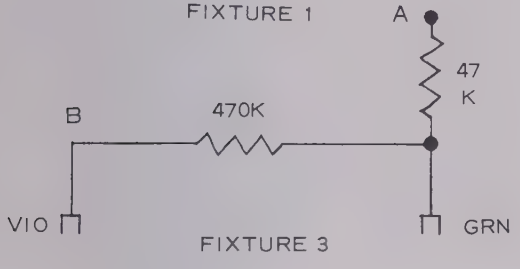
It is best to first operate the unit open loop. This is accomplished best by hooking the amplifier up with resistive feedback and driving the amplifier from an external oscillator. In this manner it can first be determined if the amplifier is operating properly and, if not, corrections can be made. Once it is determined that the amplifier is operating properly, proper operation of the hysteresis switch and the output switch can be determined. Once all three are functioning properly, the unit will oscillate properly.



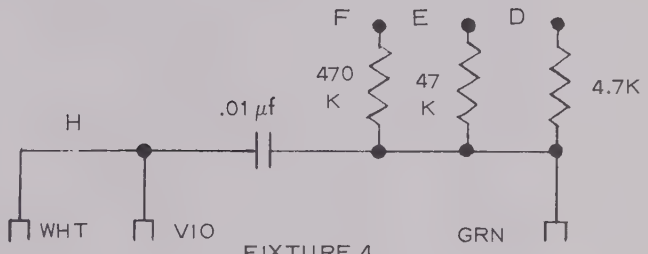
FIXTURE 1



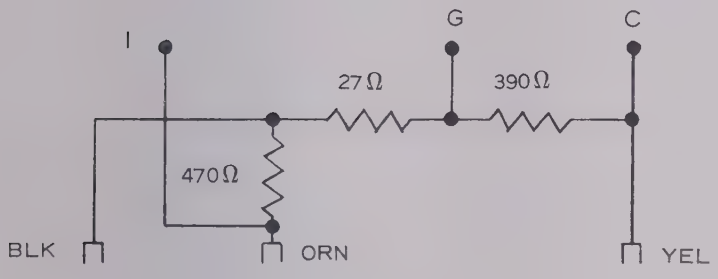
FIXTURE 2



FIXTURE 3



FIXTURE 4

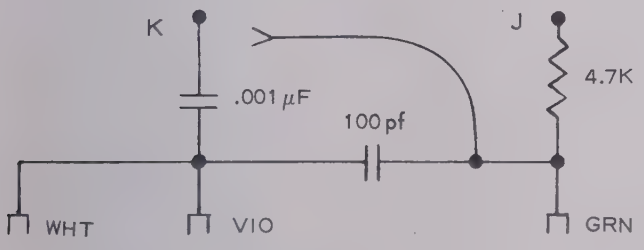


FIXTURE 5

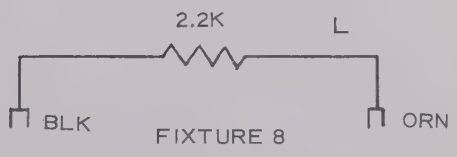
FIXTURE 6

CLIP

ELCO CONNECTOR

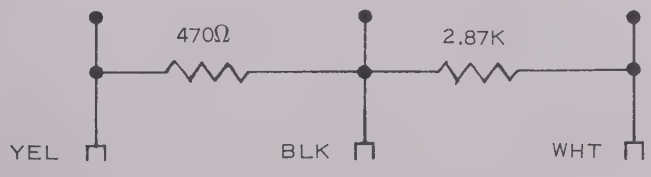


FIXTURE 7



FIXTURE 8

FIXTURE 9



FIXTURE 10

FIXTURE 11

SERVICE KIT SK – 102

FIGURE IV–1

Connect power to the main board using Fixture 2. Mount Fixture 3 to the amplifier and Fixture 5 to the output switch and the emitter follower. Connect the scope to point B and ground (black elco pin). Connect point A to ground using Fixture 6. Turn on power. Point B should be within 0.1 volts from ground. Turn power off and remove Fixture 6. Connect oscillator to point A and ground. Set oscillator for 1 kc (sine or triangle) and 0.7 volts peak to peak output. The oscillator must have an output symetrical about ground; if not, connect the oscillator to point A through an 0.1 mfd, or larger, capacitor, and connect a 10 K resistor between point A and ground. Turn on power. Amplifier output at point B should be 7 volts p-p symetrical about ground.

If the amplifier is not operating properly, first check the chopper oscillator. The waveform at the collector of Q16 should be a 1500 cycle square wave of plus six and minus six volt amplitude. The waveform at the collector of Q20 should be plus six and minus three volts. The waveform on the emitter of Q34 should be a 1500 cycle wave with one-half clamped very close to ground. The other half of the "square wave" will have curvature to it, but should average minus about one-half volt. If it is, it indicates that the chopper amplifier is operating properly, but the wideband amplifier is not. A large square wave on the emitter of Q34 should produce a volt or so of DC across C28. If it does not, check for opens or shorts. If no square wave appears at the emitter of Q34, the chopper amplifier is not operating properly. If the square wave is large, unsolder one end of C37 which connects the fail safe circuit. If the amplifier now operates properly the trouble is in the hysteresis switch, the output switch, or the fail safe circuit. If it becomes necessary to change Q19, R105 and R106 will have to be changed so that no visible difference can be noticed on the emitter of Q34 while alternately opening or shorting to ground the green pin of the wideband amplifier.

If it is determined that the chopper amplifier is operating properly, but the wideband amplifier is not, trace the signal through to determine the fault.

R66 is adjusted to position the wideband amplifier for zero output with zero input. With the input (Point A) shorted to ground, the output (Point B)

should be within .1 volt of ground. If R66 is not set properly, the symmetry of the normal triangle output will not be balanced in time. Excessive curvature of the triangle wave is caused by low gain.

Once it is determined that the amplifier is operating properly, the hysteresis switch and output switch may be checked for proper operation. A sine wave applied to the input of the amplifier should produce a sine wave on the output of the amplifier. A glitch should be noted on this output sine wave occurring at approximately plus and minus 2.5 volts. This occurs at the firing of the hysteresis and output switches. The output square wave of the hysteresis switch may be observed by looking across R34. It should run between plus and minus 4 volts. The output of the output switch may be observed by looking at Point C. It should be approximately plus and minus 5.3 volts. Use extreme care not to short point C to anything. Before checking for a fault in the output switch, make certain that the hysteresis switch is functioning properly.

Shorted transistors may be identified in circuit using a low voltage battery-operated ohmmeter, such as a Triplett or a Simpson. A line operated VTVM is not recommended, as transients caused by connection to the power line may damage the transistors.

The main board may be run as an oscillator once it is ascertained that the amplifier, hysteresis switch and output switch are functioning properly. Replace Fixture 3 with Fixture 4. Connect point C to point D using Fixture 6. Turn on power. The main board should oscillate at about 10 kc. Observe the triangle wave at point H and the square wave at points C and I. Adjust R32 for triangle wave symmetry about ground. The top end of the frequency dial (reading of 10) is simulated by connecting point C to points D, E, and F. The bottom end of the dial (reading of 0.8) is simulated by connecting Point G to points D, E, and F. To adjust R66 connect the scope to point I and observe the time symmetry of the two halves of the square wave. Connect point G to points D, E, and F in turn and adjust R66 for the best time symmetry for all three cases. When R66 is properly adjusted, all three square waves should have time symmetry within 1%.

Fixtures 4 and 7 connect the output of the integrator to the super emitter follower. Observe the output of the super emitter follower by connecting

the scope to the gray elco pin on the main board.

Fixture 7 causes the main board to oscillate at 100 kc and 1 mc. Replace Fixture 4 with Fixture 7. Connect point C to point J. The unit will oscillate at 100 kc when the loose clip is connected to point K. If any transistors in the high frequency amplifier have been replaced, check for clean triangle waveform at 100 kc.

SINE BOARD CHECKOUT

The sine board may be checked out external to the chassis. Mount the sine board to the main board and connect the four leads. Connect Fixtures 2, 4, and 5. Connect point C to point D. Connect Fixture 8 and observe the sine output at point L. With the sine board now accessible it may be easily worked on. If excessive distortion is evident due to a bad diode, transistor, or resistor in the sine shaping circuit, it may be readily determined by using a distortion analyzer and observing the residual output. Each component in the sine shaping circuit has a predominant effect on a particular portion of the sine wave. If a transistor in the sine amplifier has been replaced, it may be necessary to change R527 and/or R536.

MODEL 103 POWER AMPLIFIER

In the event of loss of output of any function from this amplifier, it should first be determined if there is an input. Using an oscilloscope, examine first the wiper of SW2 for either triangle, sine or square waves, dependent upon setting of SW2. Next, R20 should be proven in much the same manner. On the amplifier itself, Q601 and Q602 collectors should be examined for a signal present. If Q601 or Q602 are changed, it will be necessary to adjust R602 for DC offset of less than .1 volt and R608 should be adjusted for full output of 30 V p-p with 5.2 V p-p triangle input from R20. Should any other components be changed, the DC offset and gain adjustments should be accomplished. Should the output waveform be clipped at peak output with mean line voltage and 600 ohm open circuit load, the cause is most likely one of the five transistors.

VCG AMPLIFIER BOARD

The VCG amplifier board contains two operational amplifiers in cascade and clamping diodes. No adjustment is normally required. Should the unit operate improperly, the following is the check-out procedure.

Remove the main board - VCG board - sine board, from the chassis assembly. Dismount the sine board from the main board. Connect power supply leads from the chassis assembly to the main board (with VCG board mounted) with Fixture 2. Connect the arm of the frequency dial pot to the grey pin on the VCG board using Fixture 9. Mount Fixture 10 to the VCG and main board. Clip Fixture 11 to the end of C19 adjacent to R64. Check that all other loose pins are free from shorting together and that the power supply leads are free and clear. Using a #2 phillips screwdriver, rotate switch wafer on power supply to turn power on.

By alternately connecting the elco pin end of Fixture 11 to the red (+6v) and brown (-6v) elco pins on the left end of the main board, the integrator may be forced to a minus and plus output which in turn forces the output switch (Q12 - Q15, yellow elco pin) to -5.2v and +5.2v respectively. The input voltage to the cascaded amplifiers is determined by the dial setting and is applied via the grey elco pin. The position of the dial controls the voltage at the grey pin, which in turn controls the clamping voltage at the white pin. Shifting Fixture 11 between +6v and -6v switches the white pin to the minus clamp voltage and the plus clamp voltage. If the VCG is operating properly, the plus and the minus clamp voltages will be equal. At a dial setting of 0.5, the voltage at the grey pin should be approximately 0.3v which should cause a voltage at the white pin of approximately $\pm$0.15v. A dial setting of 10 produces a voltage at the grey pin of approximately 5.8v which produces a voltage at the white pin of $\pm$3v. R820 and R824 are selected for equal voltages at the bottom of the dial (0.15v). The ratio of R818 to R825 determines the balance in voltages at the high side of the dial (3v). The plus and minus voltages should match each other within 1%.

MODEL 101R, 102R and 104R BATTERY CHARGER

The battery charger is a simple constant current source which supplies

current necessary for operating the generator as well as charging the batteries. The charger charges the two batteries in series. Ground is the center point of the two batteries, thus they are necessary for proper operation of the generator. The plus six and minus six volt leads draw the same current.

The charger, battery combination is designed to operate in three modes. (1) Instrument turned off but plugged into AC line: A trickled charge of approximately 5 ma maintains the battery at full charge. (2) Instrument plugged in and turned on: Batteries are charged at normal charge rate of 30 ma, (adjustable to 100 ma). (3) Instrument turned on but not plugged in: Batteries operate the unit for a maximum of 8 hours.

The charger is normally set so that it delivers 140 ma, 110 ma to the generator, and 30 ma to the batteries. With this setting, forty hours are required for a complete charge, however, the batteries will not be damaged by continuous charging. The charger may be set to deliver 110 ma to the generator and 100 ma to the batteries. With this setting, only fourteen hours are required for a complete charge, but care should be taken to avoid overcharging. To set the charge current, connect an ammeter in series with either the red or brown lead to the batteries, and adjust R401 for the proper charge current, either 30 ma or 100 ma.

SECTION V

PARTS LIST

CAPACITORS

Tolerance ± 10% unless otherwise indicated.

CKT. NO.		DESCRIPTION		PART NO.	MFG.
C1	10 mfd	Mylar	200 v ±1%	101-C1	Wav
C2	0.1 mfd	Poly	100 v ±1%	1PJ-104F	Arc
C3	1000 pfd	Mica	500 v ±1%	DM-20-102F	Arc
C4	82 pfd	Mica	500 v ±5%	DM-15-820J	Arc
C5	4.5-25 pfd	Cer. Var.	500 v	825AZ	CRL
C6	68 pfd	Cer	1000 v	DD680	CRL
C7	68 pfd	Cer	1000 v	DD680	CRL
C8	100 mfd	Elect	12 v -20±150%	NLW100-12	CDE
C9	0.1 mfd	Cer	10 v -20+80%	UK10-104	CRL
C10	470 pfd	Cer	1000 v	DD471	CRL
C11	470 pfd	Cer	1000 v	DD471	CRL
C12	0.1 mfd	Cer	10 v -20+80%	UK10-104	CRL
C13	0.1 mfd	Mylar	100 v	WMF1P1	CDE
C14	220 pfd	Cer	1000 v	DD221	CRL
C15	220 pfd	Cer	1000 v	DD221	CRL
C16	0.1 mfd	Mylar	100 v	WMF1P1	CDE
C17	0.01 mfd	Mylar	100 v	WMF1S1	CDE
C18	0.01 mfd	Mylar	100 v	WMF1S1	CDE
C19	0.33 mfd	Mylar	100 v	WMF1P33	CDE
C20	0.01 mfd	Mylar	100 v	WMF1S1	CDE
C21	0.01 mfd	Mylar	100 v	WMF1S1	CDE
C22	330 pfd	Cer	1000 v	DD331	CRL
C23	0.01 mfd	Mylar	100 v	WMF1S1	CDE
C24	0.33 mfd	Mylar	100 v	WMF1P33	CDE
C25	0.01 mfd	Mylar	100 v	WMF1S1	CDE
C26	100 pfd	Cer	1000 v	DD101	CRL
C27	680 pfd	Cer	1000 v	DD681	CRL
C28	1.0 mfd	Mylar	100 v ±20%	MD1A105	ELP
C29	0.1 mfd	Mylar	100 v	WMF1P1	CDE
C30	0.01 mfd	Mylar	100 v	WMF1S1	CDE
C31	100 pfd	Cer	1000 v	DD101	CRL
C32	330 pfd	Cer	1000 v	DD331	CRL
C33	0.01 mfd	Mylar	100 v	WMF1S1	CDE
C34	1000 pfd	Cer	1000 v	DD102	CRL
C35	0.1 mfd	Cer	10 v -20+80%	UK10-104	CRL
C36	100 mfd	Elect	12 v -20±150%	NLW100-12	CDE

CAPACITORS (continued)

CKT. NO.		DESCRIPTION			PART NO.	MFG.
C37	0.01 mfd	Mylar	100 v		WMF1S1	CDE
C38	22 pfd	Cer	1000 v		DD220	CRL
C39	10 pfd	Cer	1000 v		DD100	CRL
C40	330 pfd	Cer	1000 v		DD331	CRL
C41	0.1 mfd	Cer	10 v	-20+80%	UK10-104	CRL
C42	0.47 mfd	Cer	10 v	-20+80%	UK10-474	CRL
C301	2000 mfd	Elect	12 v		BR2000-12	CDE
C302	2000 mfd	Elect	12 v		BR2000-12	CDE
C401	1000 mfd	Elect	25 v		BR1000-25	CDE
C501	1000 pfd	Cer	1000 v		DD102	CRL
C502	1000 pfd	Cer	1000 v		DD102	CRL
C503	1000 pfd	Cer	1000 v		DD102	CRL
C504	1000 pfd	Cer	1000 v		DD102	CRL
C505	1000 pfd	Cer	1000 v		DD102	CRL
C506	1000 pfd	Cer	1000 v		DD102	CRL
C601	22 pfd	Cer	1000 v		DD220	CRL
C602	22 pfd	Cer	1000 v		DD220	CRL
C603	3-12 pfd	Cer. Var.	500 v		825FZ	CRL
C604	.01 mfd	Cer	50 v	-20+80%	CK103	CRL
C605	.0015 mfd	Cer	1000 v		DD152	CRL
C606	.01 mfd	Cer	50 v	-20+80%	CK103	CRL
C701	1000 mfd	Elect	25 v		BR1000-25	CDE
C702	1000 mfd	Elect	25 v		BR1000-25	CDE
C703	2000 mfd	Elect	12 v		BR2000-12	CDE
C704	2000 mfd	Elect	12 v		BR2000-12	CDE
C801	10 pfd	Cer	1000 v		DD100	CRL
C802	10 pfd	Cer	1000 v		DD100	CRL
C803	100 pfd	Cer	1000 v		DD101	CRL
C804	100 pfd	Cer	1000 v		DD101	CRL
C805	.01 mfd	Cer	50 v	-20+80%	CK103	CRL
C806	10 pfd	Cer	1000 v		DD100	CRL
C807	100 pfd	Cer	1000 v		DD101	CRL
C808	100 pfd	Cer	1000 v		DD101	CRL

DIODES

CR1	1N3754		RCA
CR2	1N3754		RCA
CR3	1N751	Zener	Motr
CR4	1N3754		RCA
CR5	1N4009		GE
CR6	1N4009		GE
CR7	TI51		TI

DIODES (continued)

CKT. NO.		DESCRIPTION	PART NO.	MFG.
CR8	TI51			TI
CR9	1N4009			GE
CR10	TI51			TI
CR11	TI51			TI
CR12	1N751	Zener		Mot
CR301	1N3754			RCA
CR302	1N3754			RCA
CR303	1N3754			RCA
CR304	1N3754			RCA
CR401	1N3754			RCA
CR402	1N3754			RCA
CR403	1N751	Zener		Mot
CR404	1N3193			RCA
CR501,5	1N4009	Matched Pair	102-CR503,4	Wav
CR503,4	1N4009	Matched Pair	102-CR503,4	Wav
CR502,6	1N4009	Matched Pair	102-CR503,4	Wav
CR507	TI51			TI
CR508	TI51			TI
CR601	1N770	Germanium		Syl
CR602	1N770	Germanium		Syl
CR701	1N3754			RCA
CR702	1N3754			RCA
CR703	1N3754			RCA
CR704	1N3754			RCA
CR705	1N3754			RCA
CR706	1N3754			RCA
CR707	1N3754			RCA
CR708	1N3754			RCA
CR801,2	1N4009	Matched Pair	104-CR801,2	Wav
CR803	1N4009			GE
CR804,5	1N4009	Matched Pair	104-CR801,2	Wav

TRANSISTORS

Q1	2N1304		TI
Q2	2N1305		TI
Q3	2N1305		TI
Q4	2N1305		TI
Q5	2N1304		TI
Q6	2N1304		TI
Q7	2N1305		TI
Q8	2N2257		Mot

TRANSISTORS (continued)

CKT. NO.	DESCRIPTION	PART NO.	MFG.
Q9	2N711B		TI
Q10	2N2257		Mot
Q11	2N711B		TI
Q12	2N2257		
Q13	2N967	Selected set	101-Q12-15	Wav
Q14	2N2257	of four	
Q15	2N967		
Q16	2N1305		TI
Q17	2N711B		TI
Q18	2N797	Selected	101-Q18	Wav
Q19	2N2714		GE
Q20	2N1305		TI
Q21	2N2716		GE
Q22	2N2716		GE
Q23	2N967		Mot
Q24	2N1305		TI
Q25	2N967		Mot
Q26	2N967		Mot
Q27	2N1305		TI
Q28	2N1305		TI
Q29	2N1305		TI
Q30	2N1304		TI
Q31	2N1305		TI
Q32	2N2257		Mot
Q33	2N2257		Mot
Q34	2N1305		TI
Q35	2N1308		TI
Q36	2N711B		TI
Q401	2N555		Mot
Q502, 3, 4	2N1304	Matched set of 3	102-Q502-4	Wav
Q506, 7, 8	2N1305	Matched set of 3	102-Q506-8	Wav
Q501, 5	2N1304, 2N1305	Matched pair	102-Q501, 5	Wav
Q509	2N711B		TI
Q510	2N2257		Mot
Q511	2N2257		Mot
Q512	2N711B		TI
Q601	2N2959		Mot
Q602	2N2959		Mot
Q603	2N3134		Mot
Q604	2N3134		Mot
Q605	2N2959		Mot
Q801, 2	2N2716	Matched pair	Wav

TRANSISTORS (continued)

CKT. NO.		DESCRIPTION	PART NO.	MFG.
Q803	2N967			Mot
Q804	2N967			Mot
Q805	2N2257			Mot
Q806, 7	2N2716	Matched pair		Wav
Q808	2N967			Mot
Q809	2N967			Mot
Q810	2N711B			TI

RESISTORS

Resistors are fixed composition, 1/2W, ±10%, AB unless otherwise indicated.

R1	4.7K				
R2	4.7K				
R3	100 ohm				
R4	100 ohm				
R5	68 ohm				
R6	68 ohm				
R7	1K				
R8	1K	W. W. Var.	1/4w	275-1-102	BOR
R9	1K				
R10					
R11	1K	W. W. Var.	1/4 w	275-1-102	BOR
R12	560 ohm				
R13 (101-103)	500 ohm	Comp. Var.	2 w, ±10%	CU5011	OHM
(104, 105)	15K	Comp. Var.	2 w, ±10%	CU1531	OHM
R14	50 ohm	Comp. Var.	2 w, ±10%	CU5001	OHM
R15	470 ohm				
R16	1K	Comp. Var.	2 w, ±10%	CU1021	OHM
R17 (101-103)	4.64K	Metal Film	1/2 w, ±1%	CEC T-0	IRC
(104, 105)	2.87K	Metal Film	1/2 w, ±1%	CEC T-0	IRC
R18 (101-103)	46.4K	Metal Film	1/2 w, ±1%	CEC T-0	IRC
(104, 105)	28.7K	Metal Film	1/2 w, ±1%	CEC T-0	IRC
R19 (101-103)	464K	Metal Film	1/2 w, ±1%	CEC T-0	IRC
(104, 105)	287K	Metal Film	1/2 w, ±1%	CEC T-0	IRC
R20 (101, 102)	2.5K	Comp. Var.	2 w, ±10%	CU2521	OHM
(103)	1K	Comp. Var.	2 w, ±10%	CU1021	OHM
(104)	500 ohm	Comp. Var.	.3 w, ±10%	104-R20	WAV
(105)	1K	Comp. Var.	.3 w, ±10%	105-R20	WAV
R21	6.8K				

RESISTORS (continued)

CKT. NO.		DESCRIPTION		PART NO.	MFG.
R22	390 ohm				
R23	470 ohm				
R24	470 ohm				
R25	560 ohm				
R26	1.2K				
R27	1.2K				
R28	470 ohm				
R29	220 ohm				
R30	220 ohm				
R31	470 ohm				
R32	200 ohm	W. W. Var.	1/4 w, ±10%	275-1-201	BOR
R33	560 ohm				
R34	1K				
R35	270K				
R36	47K				
R37	270K				
R38	100 ohm				
R39	100 ohm				
R40	56 ohm				
R41	47K				
R42	220 ohm				
R43	47K				
R44	4.7K				
R45	10 ohm				
R46	10 ohm				
R47	56 ohm				
R48	82K				
R49	10K				
R50	47K				
R51	220 ohm				
R52	10K				
R53	47K				
R54	220 ohm				
R55	4.7K				
R56	27K				
R57	27K				
R58	10K				
R59	18K				
R60	270K				
R61	390K				
R62	270K				
R63	47K				

RESISTORS (continued)

CKT. NO.		DESCRIPTION		PART NO.	MFG.
R64	390K				
R65	47K				
R66	200K	W. W. Var.	1/4 w, ±10%	276-1-204	BOR
R67	470K				
R68	220 ohm				
R69	2.7K				
R70	4.7K				
R71	1K				
R72	4.7K				
R73	1K				
R74	4.7K				
R75	120 ohm				
R76	470 ohm				
R77	1K				
R78	4.7K				
R79	4.7K				
R80	4.7K				
R81	120 ohm				
R82	47 ohm				
R83	330 ohm				
R84	10K				
R85					
R86	120 ohm				
R87	470K				
R88	1K				
R89	10 ohm				
R90	270 ohm				
R91	1K				
R92	47 ohm				
R93	470 ohm				
R94	27 ohm				
R95	68 ohm				
R96	1K				
R97	4.7K				
R98	470K				
R99	47 ohm				
R100	47 ohm				
R101	47 ohm				
R102	27 ohm				
R103	270K				
R104	10K				
R105					
R106					

RESISTORS (continued)

CKT NO		DESCRIPTION		PART NO.	MFG.
R107	100K				
R108	1.5K				
R109	4.42K	Metal Film	1/2 w, ±1%	CEC T-0	IRC
R110	6.65K	Metal Film	1/2 w, ±1%	CEC T-0	IRC
R111	66.5K	Metal Film	1/2 w, ±1%	CEC T-0	IRC
R112	665K	Metal Film	1/2 w, ±1%	CEC T-0	IRC
R113	270 ohm				
R114	680 ohm				
R115	100 ohm				
R401	25 ohm	W. W. Var.	10W, ±10%	1009	OHM
R402	6.8 ohm				
R403	6.8 ohm				
R404	1.5K				
R405					
R501	316 ohm	Metal Film	1/2 w, ±1%	CEC T-0	IRC
R502	316 ohm	Metal Film	1/2 w, ±1%	CEC T-0	IRC
R503	1K	Metal Film	1/2 w, ±1%	CEC T-0	IRC
R504	1K	Metal Film	1/2 w, ±1%	CEC T-0	IRC
R505	1K	Metal Film	1/2 w, ±1%	CEC T-0	IRC
R506	1K	Metal Film	1/2 w, ±1%	CEC T-0	IRC
R507	1K	Metal Film	1/2 w, ±1%	CEC T-0	IRC
R508	1K	Metal Film	1/2 w, ±1%	CEC T-0	IRC
R509	1K	Metal Film	1/2 w, ±1%	CEC T-0	IRC
R510	4.64K	Metal Film	1/2 w, ±1%	CEC T-0	IRC
R511	4.64K	Metal Film	1/2 w, ±1%	CEC T-0	IRC
R512	4.64K	Metal Film	1/2 w, ±1%	CEC T-0	IRC
R513	4.64K	Metal Film	1/2 w, ±1%	CEC T-0	IRC
R514	4.64K	Metal Film	1/2 w, ±1%	CEC T-0	IRC
R515	4.64K	Metal Film	1/2 w, ±1%	CEC T-0	IRC
R516	4.64K	Metal Film	1/2 w, ±1%	CEC T-0	IRC
R517	4.64K	Metal Film	1/2 w, ±1%	CEC T-0	IRC
R518	511 ohm	Metal Film	1/2 w, ±1%	CEC T-0	IRC
R519	511 ohm	Metal Film	1/2 w, ±1%	CEC T-0	IRC
R520	7.5K	Metal Film	1/2 w, ±1%	CEC T-0	IRC
R521	178 ohm	Metal Film	1/2 w, ±1%	CEC T-0	IRC
R522	1.5K	Metal Film	1/2 w, ±1%	CEC T-0	IRC
R523	100 ohm	W. W. Var.	1/4 w, ±10%	275-1-501	BOURNS
R524	100 ohm	W. W. Var.	1/4 w, ±10%	275-1-501	BOURNS
R525	100 ohm	W. W. Var.	1/4 w, ±10%	275-1-501	BOURNS
R526	10 ohm				
R527	1K				
R528	2.7K				
R529	1K		1/2 w, ±1%		

RESISTORS (continued)

CKT. NO.		DESCRIPTION		PART NO.	MFG.
R530	560 ohm				
R531	1K				
R532	330 ohm				
R533	56 ohm				
R534	910Ω				
R535	2.7K				
R536	10K				
R537	3.16K	Metal Film	1/2 w, ±1%	CEC T-0	IRC
R601	1K				
R602	≈ 40K				
R603	1.5K				
R604	6.8K				
R605	1K				
R606	1K				
R607	8.2K				
R608	≈ 30K				
R609	3.3K				
R610	3.3K				
R611	100 ohm				
R612	150 ohm		2 w, ±10%		
R613	150 ohm		2 w, ±10%		
R614	4.7K				
R615	47 ohm				
R801	56.2K	Metal Film	1/2 w, ±1%	CEC T-0	IRC
R802	1.5K				
R803	46.4K	Metal Film	1/2 w, ±1%	CEC T-0	IRC
R804	28.7K	Metal Film	1/2 w, ±1%	CEC T-0	IRC
R805	100 ohm	Metal Film	1/2 w, ±1%	CEC T-0	IRC
R806	4.64K	Metal Film	1/2 w, ±1%	CEC T-0	IRC
R807	4.64K	Metal Film	1/2 w, ±1%	CEC T-0	IRC
R808	100 ohm	Metal Film	1/2 w, ±1%	CEC T-0	IRC
R809	4.64K	Metal Film	1/2 w, ±1%	CEC T-0	IRC
R810	12K				
R811	4.64K	Metal Film	1/2 w, ±1%	CEC T-0	IRC
R812	1K	Metal Film	1/2 w, ±1%	CEC T-0	IRC
R813	4.64K	Metal Film	1/2 w, ±1%	CEC T-0	IRC
R814	1K				
R815	390 ohm				
R816	1.2K	Metal Film	1/2 w, ±1%	CEC T-0	IRC
R817	2K	Metal Film	1/2 w, ±1%	CEC T-0	IRC
R818	10K	Metal Film	1/2 w, ±1%	CEC T-0	IRC
R819	100 ohm	Metal Film	1/2 w, ±1%	CEC T-0	IRC

RESISTORS (continued)

CKT. NO.		DESCRIPTION		PART NO.	MFG.
R820					
R821	4.64K	Metal Film	1/2 w, ±1%	CEC T-0	IRC
R822	4.64K	Metal Film	1/2 w, ±1%	CEC T-0	IRC
R823	100 ohm	Metal Film	1/2 w, ±1%	CEC T-0	IRC
R824					
R825	10K	Metal Film	1/2 w, ±1%	CEC T-0	IRC
R826	4.64K	Metal Film	1/2 w, ±1%	CEC T-0	IRC
R827	4.7K				
R828	4.64K	Metal Film	1/2 w, ±1%	CEC T-0	IRC
R829	1K	Metal Film	1/2 w, ±1%	CEC T-0	IRC
R830	4.64K	Metal Film	1/2 w, ±1%	CEC T-0	IRC
R831	1K				
R832	1K	Metal Film	1/2 w, ±1%	CEC T-0	IRC
R833	2K	Metal Film	1/2 w, ±1%	CEC T-0	IRC
R834	1.2K	Metal Film	1/2 w, ±1%	CEC T-0	IRC

BATTERIES

B201-12	Dry Cell		1.5 v	[illegible]	[illegible]
B401-6	N. Cadmium		7.5 v	[illegible]	[illegible]
B407-12	N. Cadmium		7.5 v	[illegible]	[illegible]

FUSES

F201	1/4 amp	8AG	Instr.	[illegible]	[illegible]
F202	1/4 amp	8AG	Instr.	[illegible]	[illegible]
F301	1/4 amp	8AG	Instr.	[illegible]	[illegible]
F302	1/4 amp	8AG	Instr.	[illegible]	[illegible]
F303	3/8 amp	8AG	UL	[illegible]	[illegible]
F401	1/4 amp	8AG	Instr.	[illegible]	[illegible]
F402	1/4 amp	8AG	Instr.	[illegible]	[illegible]
F403	3/8 amp	8AG	UL	[illegible]	[illegible]
F701	3/8 amp	8AG	UL	[illegible]	[illegible]
F702	1/4 amp	8AG	Instr.	[illegible]	[illegible]
F703	1/4 amp	8AG	Instr.	[illegible]	[illegible]
F704	1/4 amp	8AG	Instr.	[illegible]	[illegible]
F705	1/4 amp	8AG	Instr.	[illegible]	[illegible]

SWITCHES

SW1	3 wafer	8 position	[illegible]	[illegible]
SW2 (101)	1 wafer	2 position	[illegible]	[illegible]
SW2 (102)	2 wafer	3 position	[illegible]	[illegible]

SWITCHES (continued)

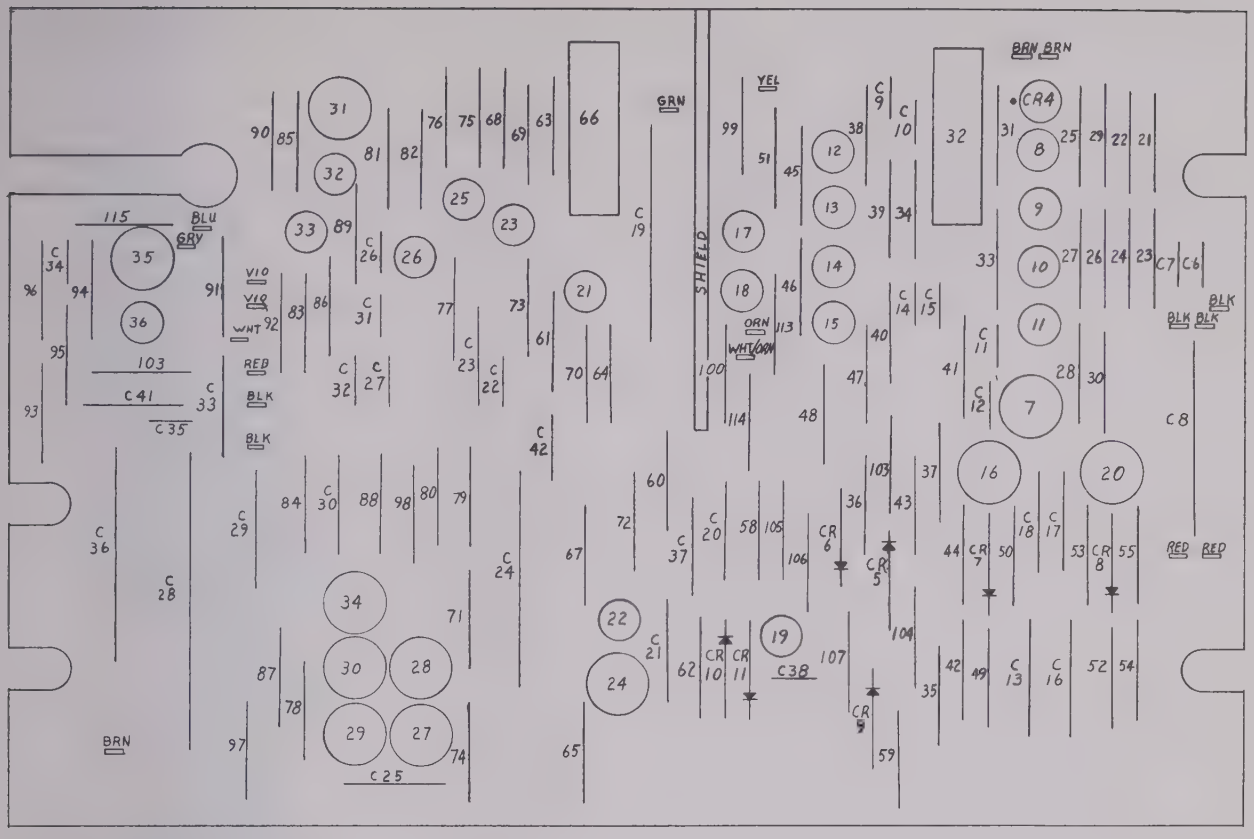
CKT. NO.		DESCRIPTION	PART NO.	MFG.
SW2 (103)	2 wafer	4 position	103-SW2	Wav
SW2 (104, 5)	1 wafer	3 position coaxial w/R20	104-SW2	Wav
SW3 (104, 5)	2 wafer	3 position	104-SW3	Wav

TRANSFORMERS

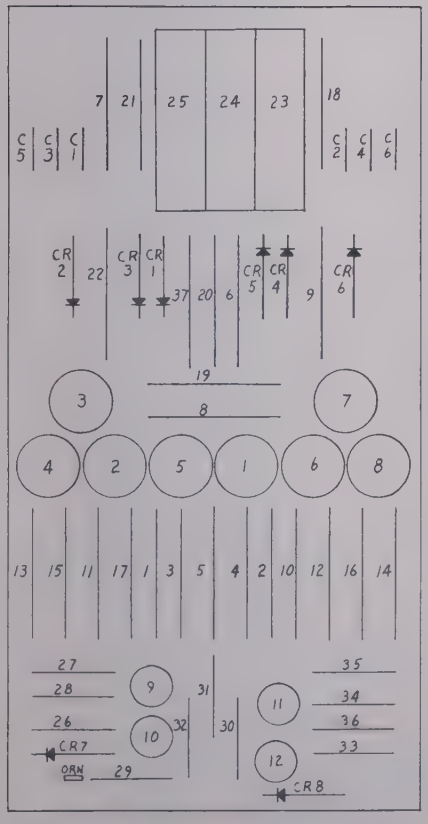
T301	115/230 v Pri			50419B	Wav
T301	12.6 v CT	1.5 a	Alternate	F25X	Tri
T401	115/230 v Pri			50419B	Wav
T701	115/230 v Pri			50433	Wav

MFG. CODE

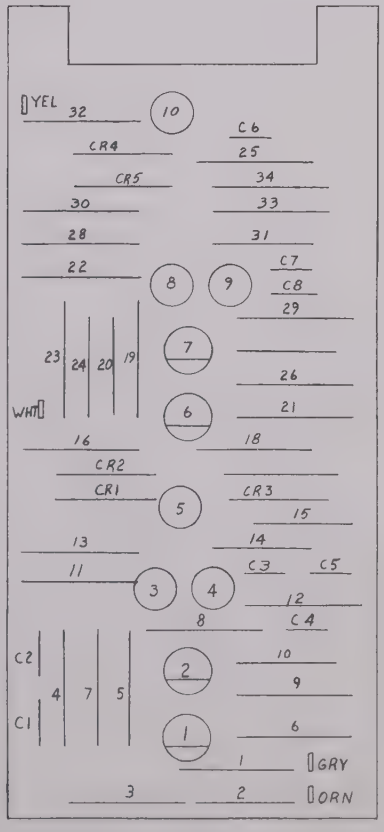
AB	Allen-Bradley
Arc	Arco Electronics
Bor	Bourns, Inc.
CDE	Cornell-Dubilier Electronics
CRL	Centralab
ELP	Elpac, Inc.
Evy	Eveready Div. Union Carbide
GE	General Electric
IRC	International Resistance Co.
LF	Littlefuse, Inc.
Mot	Motorola
Ohm	Ohmite Manufacturing Co.
RAY	Rayovac
RCA	RCA Semiconductor Division
TI	Texas Instruments
Tri	Triad Transformer Corp.
Syl	Sylvania
Wav	Wavetek



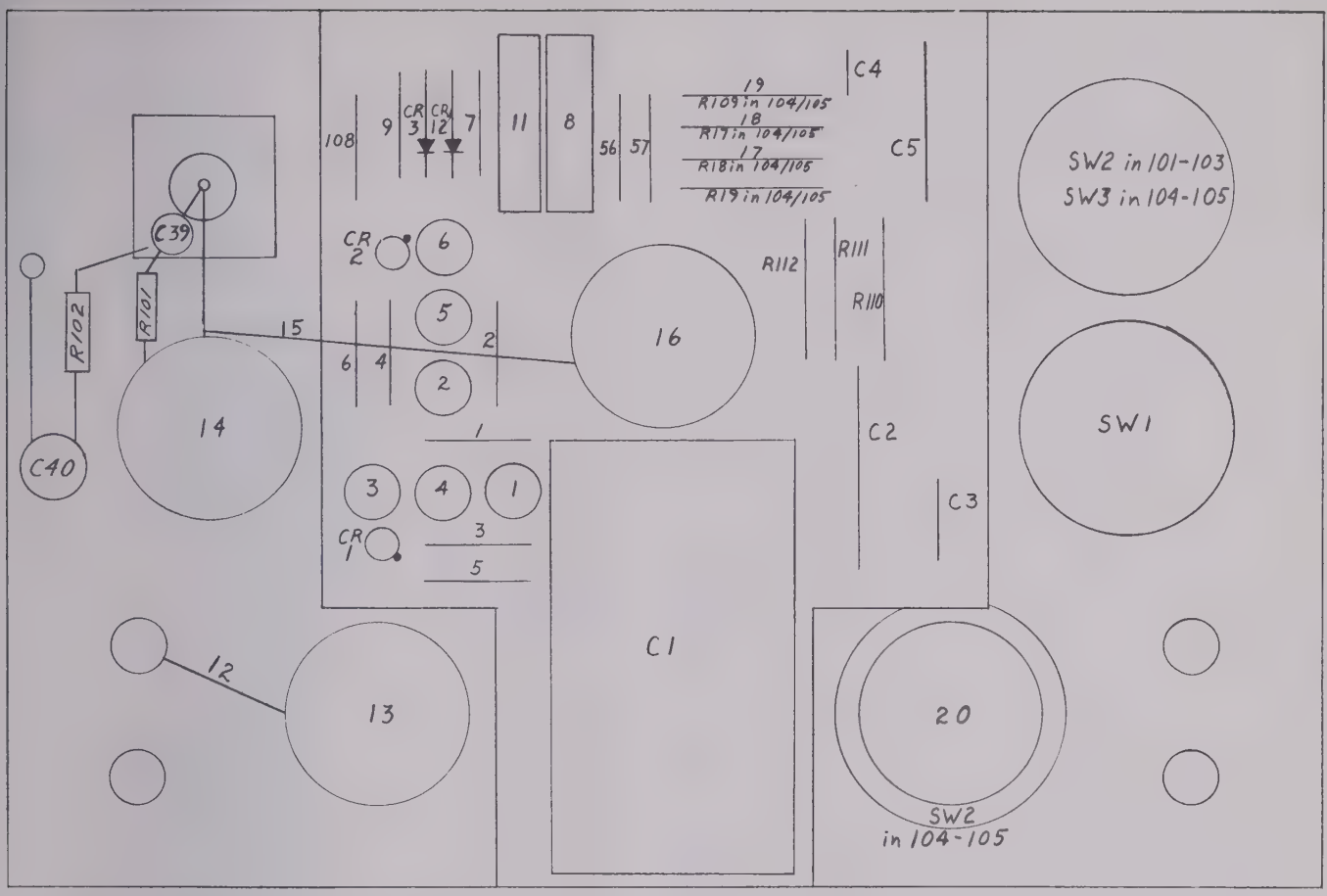
MAIN BOARD



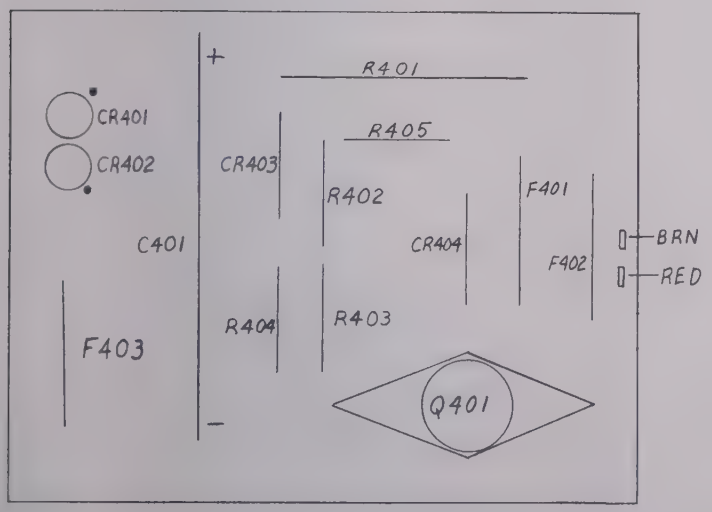
SINE CONVERTER



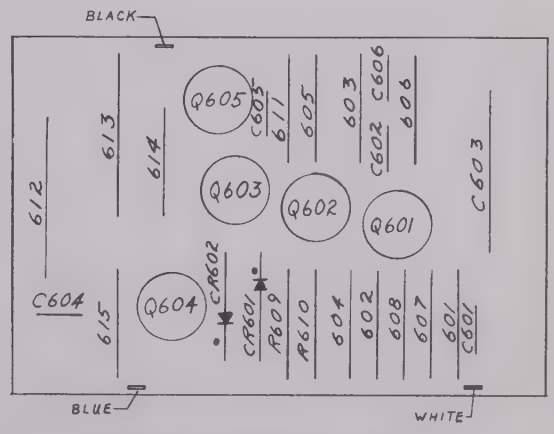
VCG AMPLIFIER



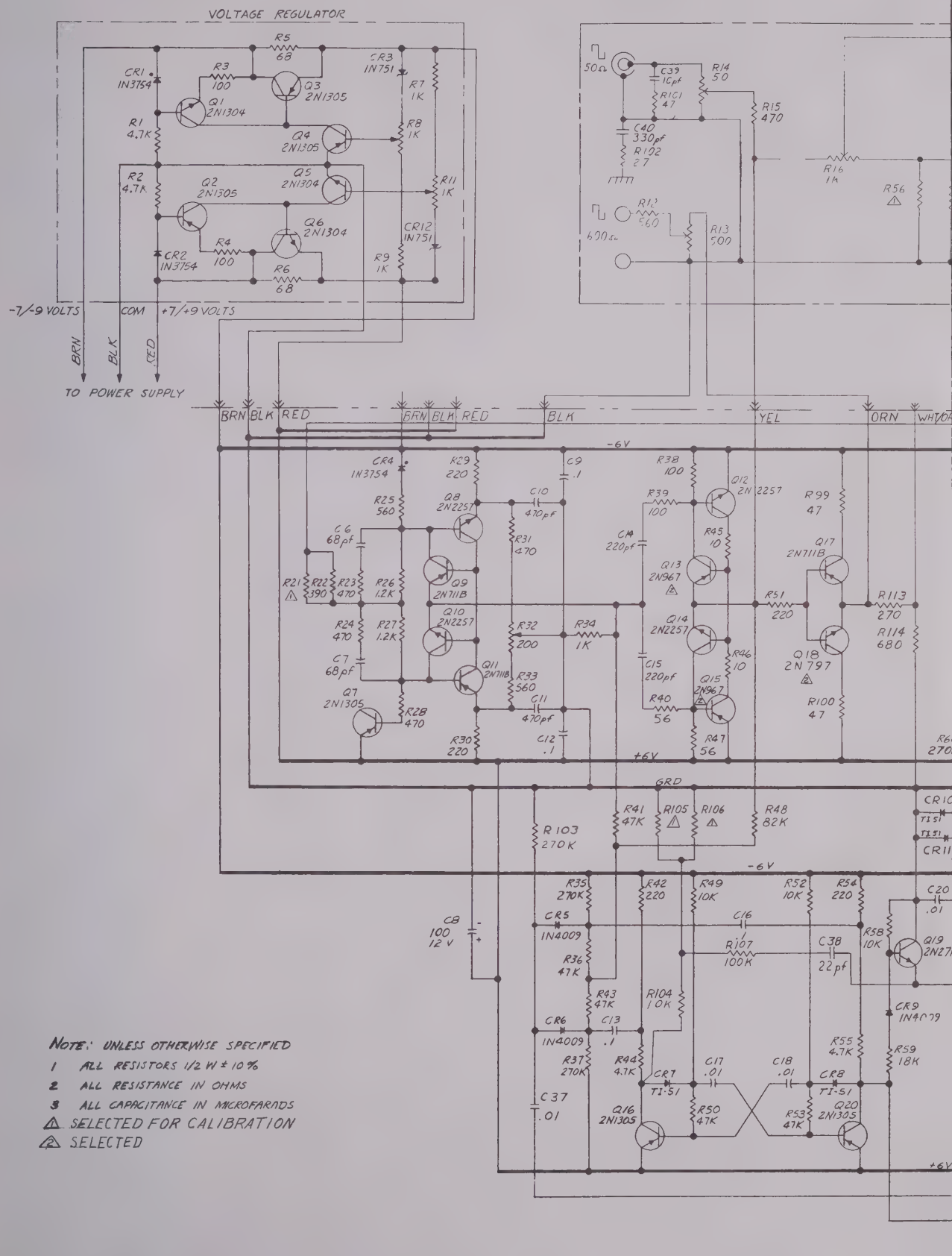
Panel Assembly



Model 101R, 102R, 104R Regulator



Model 103 Amplifier

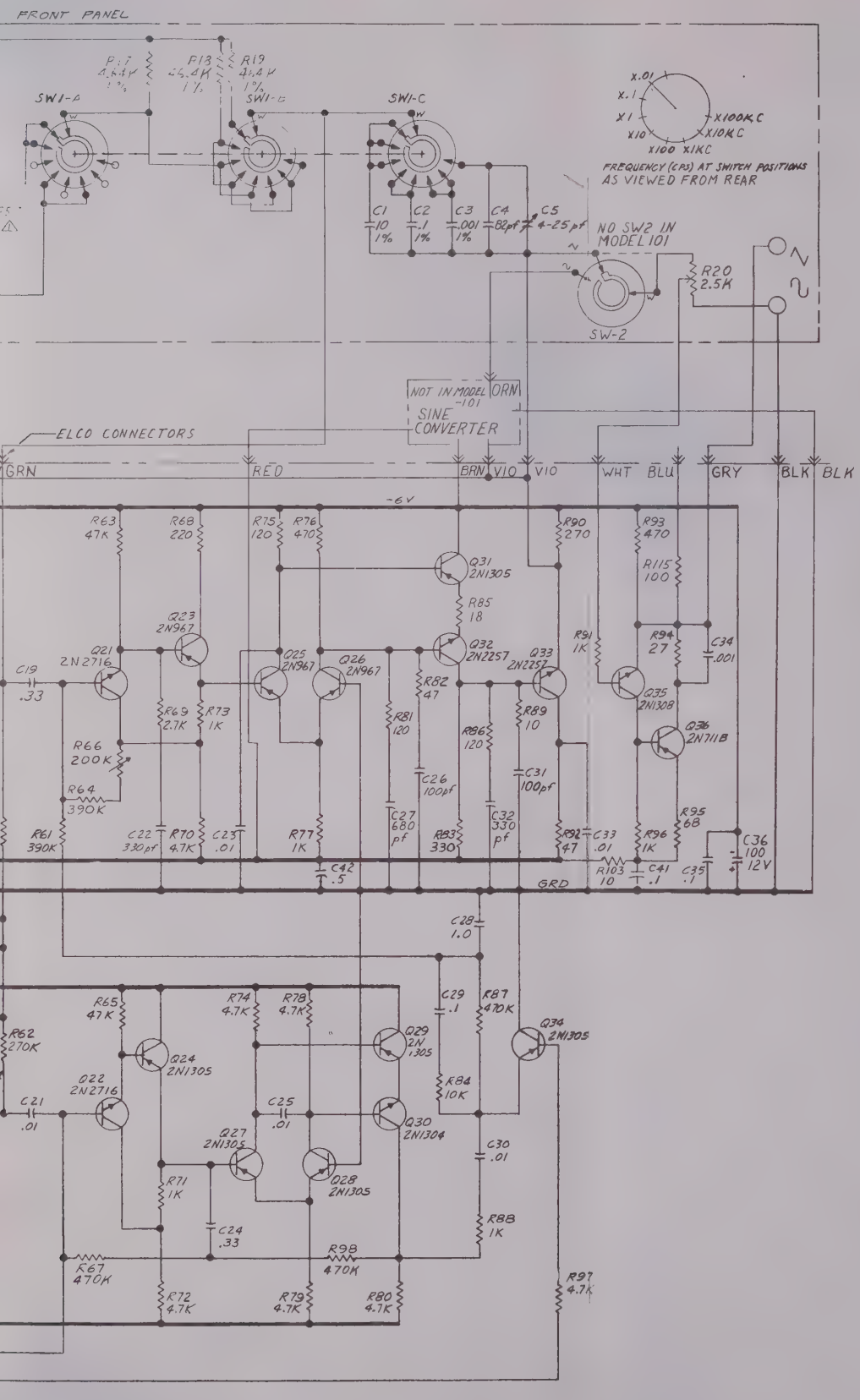


NOTE: UNLESS OTHERWISE SPECIFIED

1. ALL RESISTORS 1/2 W ± 10%
2. ALL RESISTANCE IN OHMS
3. ALL CAPACITANCE IN MICROFARADS

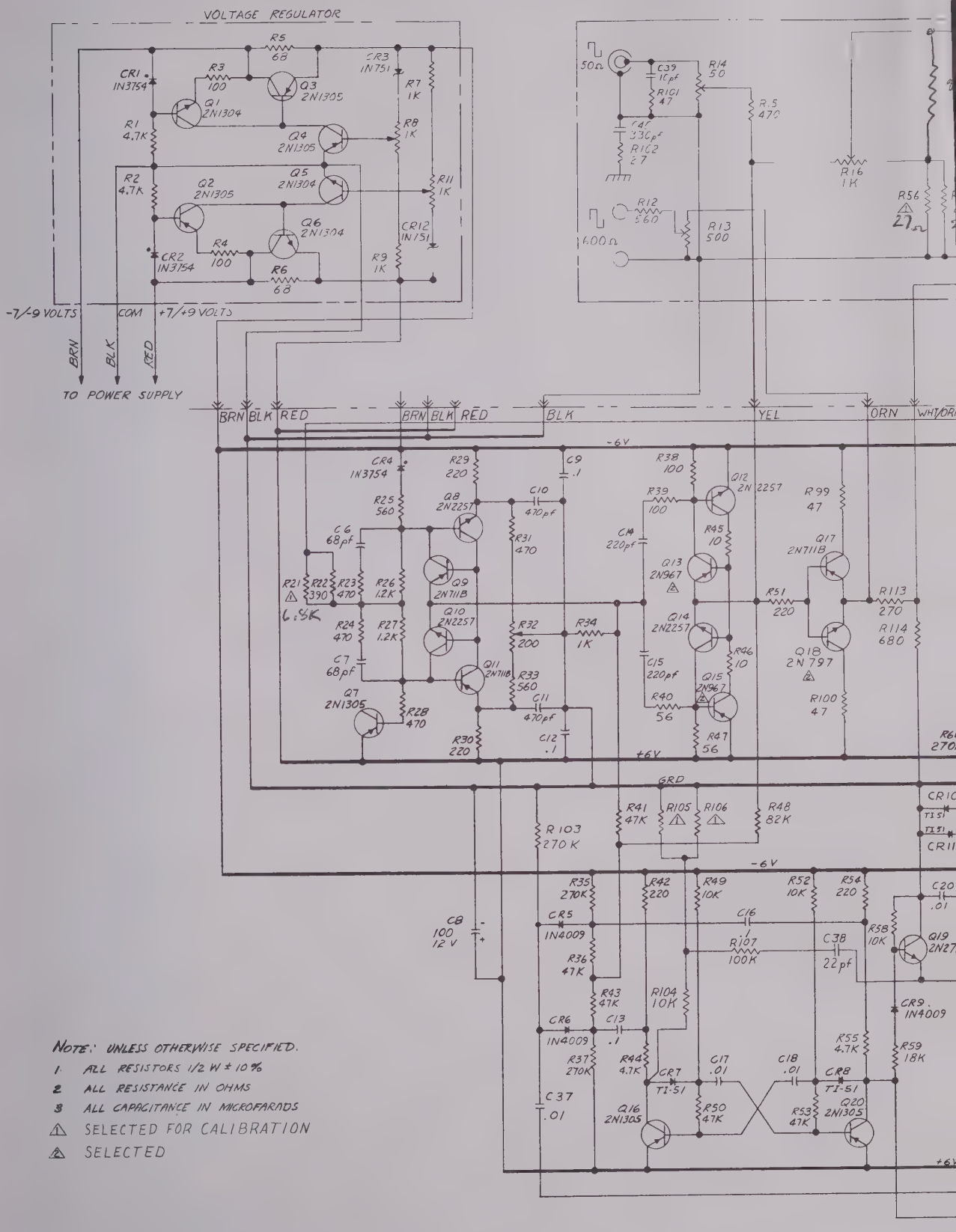
⚠ SELECTED FOR CALIBRATION

⚠2 SELECTED



THIS PRINT EFFECTIVE SER NO. 437-451 AND 465 ON

WAVETEK	8133 engineer, rd. san diego, calif.	
DRWN R Collier 7-7-64	APPR	7/8/64
schematic main board		
models 101 & 102	C31-201	

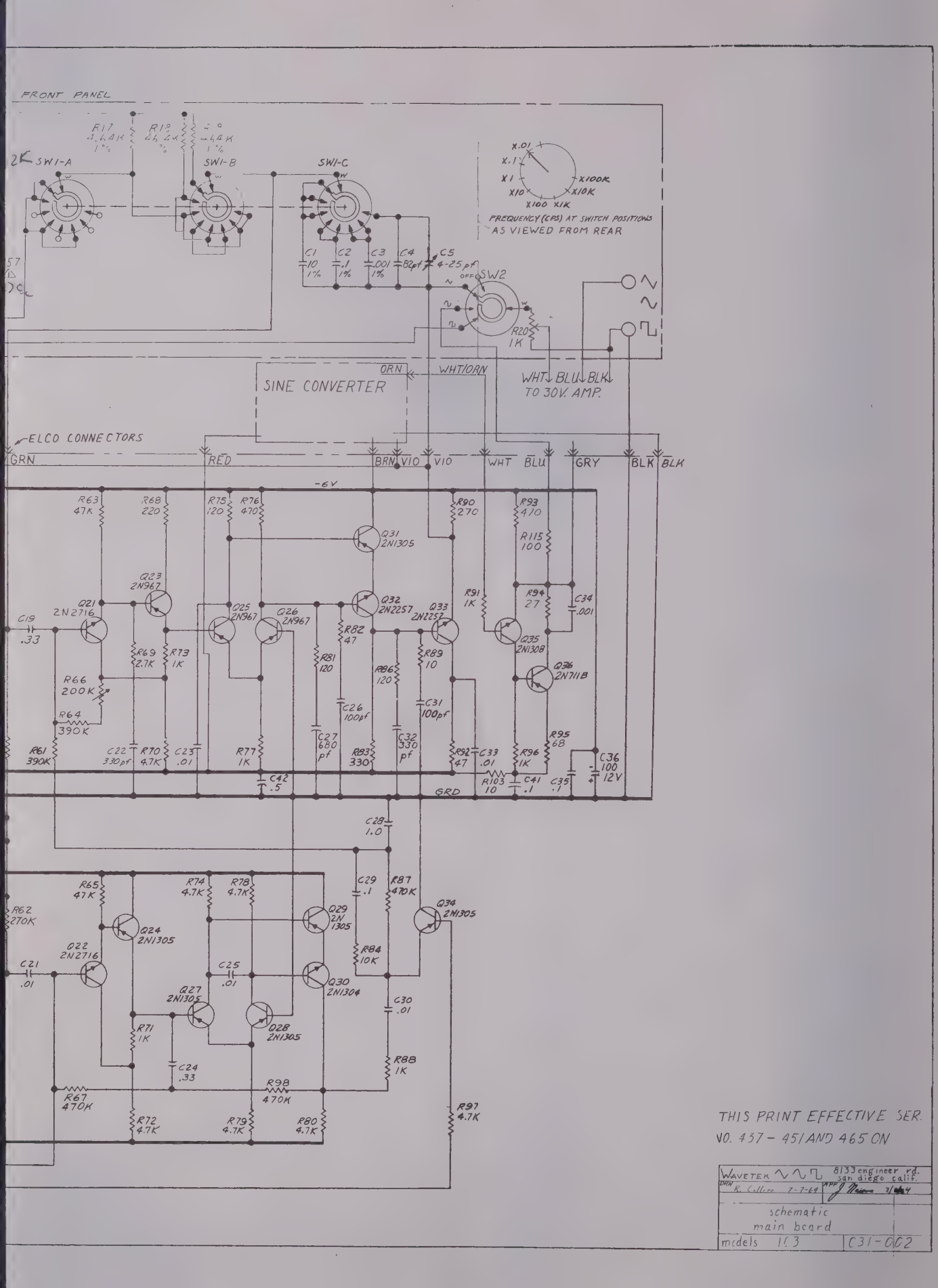


NOTE: UNLESS OTHERWISE SPECIFIED.

1. ALL RESISTORS 1/2 W ± 10%
2. ALL RESISTANCE IN OHMS
3. ALL CAPACITANCE IN MICROFARADS

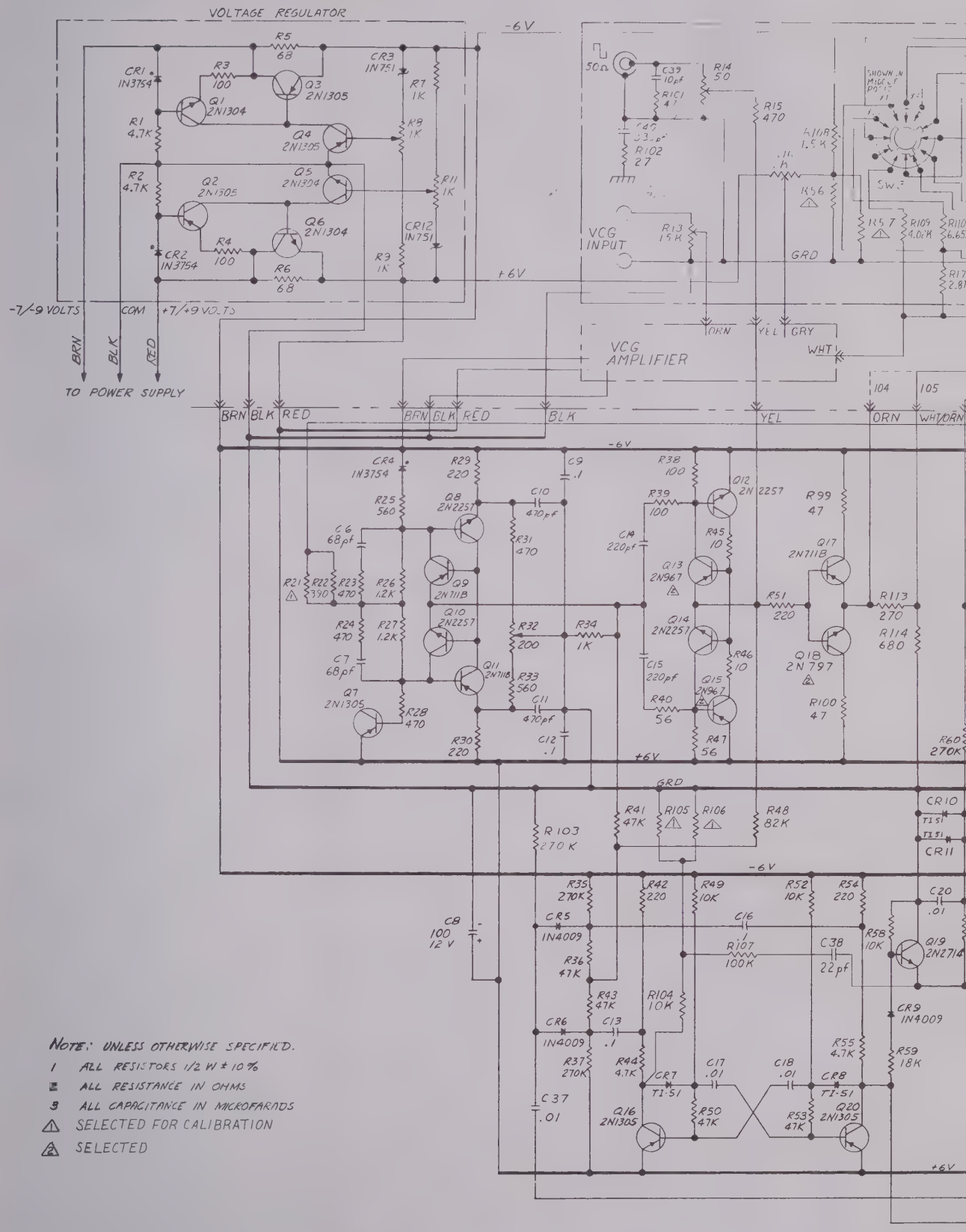
⚠ SELECTED FOR CALIBRATION

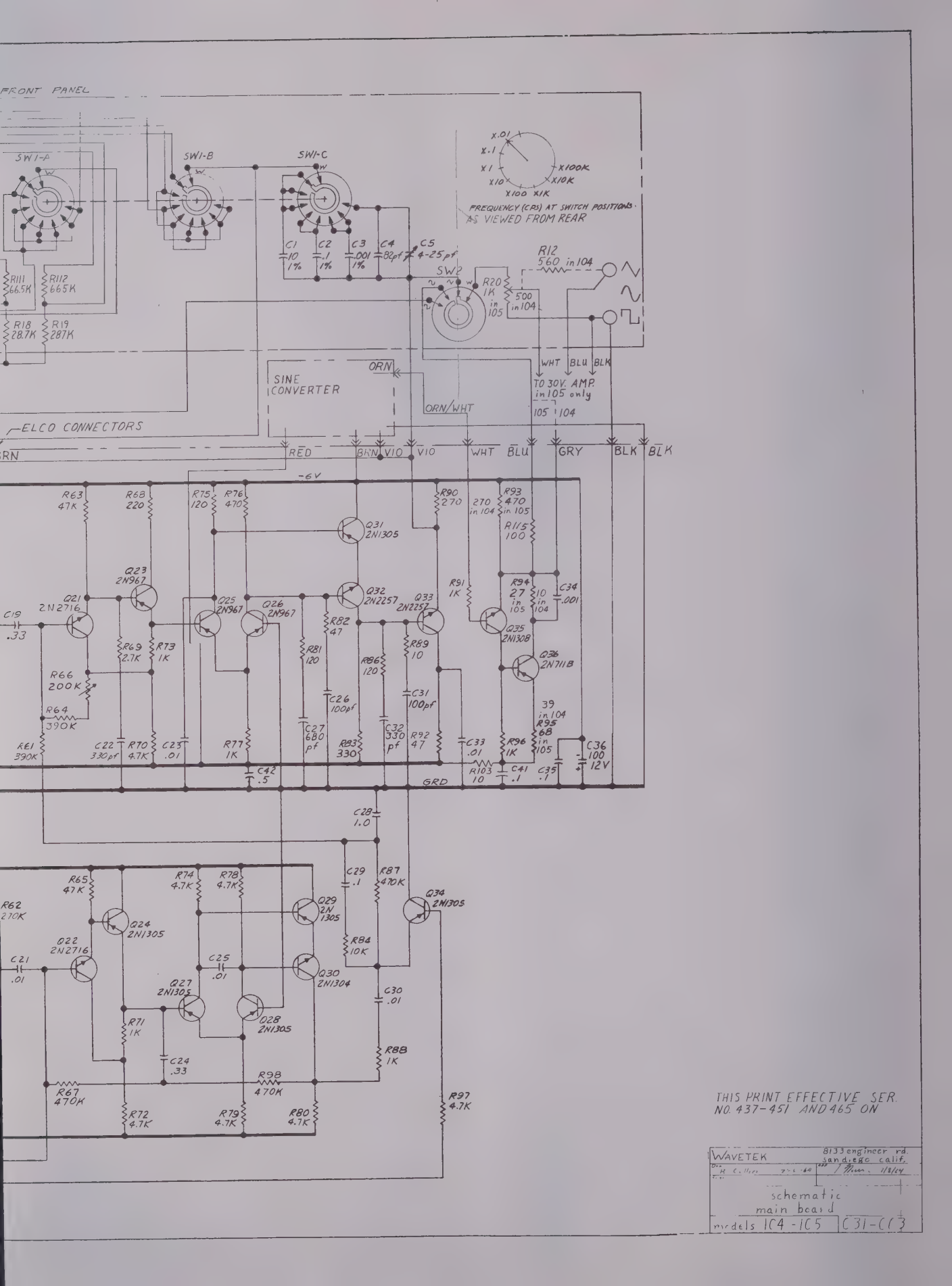
② SELECTED

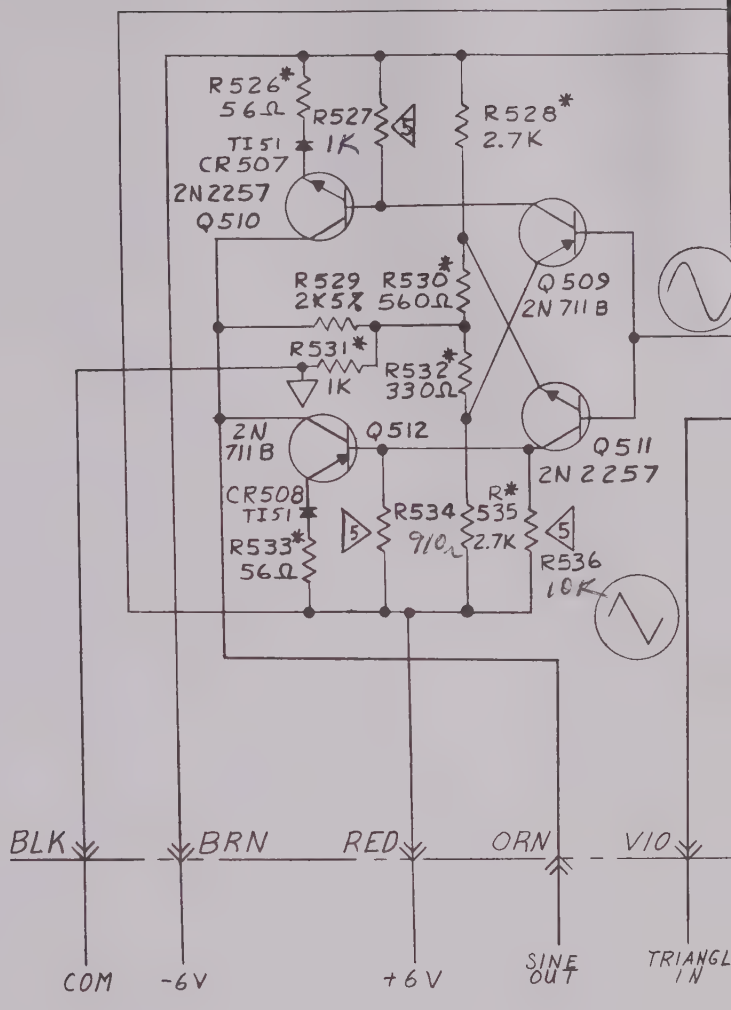


THIS PRINT EFFECTIVE SER. NO. 437 - 451 AND 465 ON

WAVETEK	8133 engineer rd. san diego calif.	
DRN K. Collier 7-7-64	APPD J. Moore 7/8/64	
schematic main board		
models 103	C31-002	

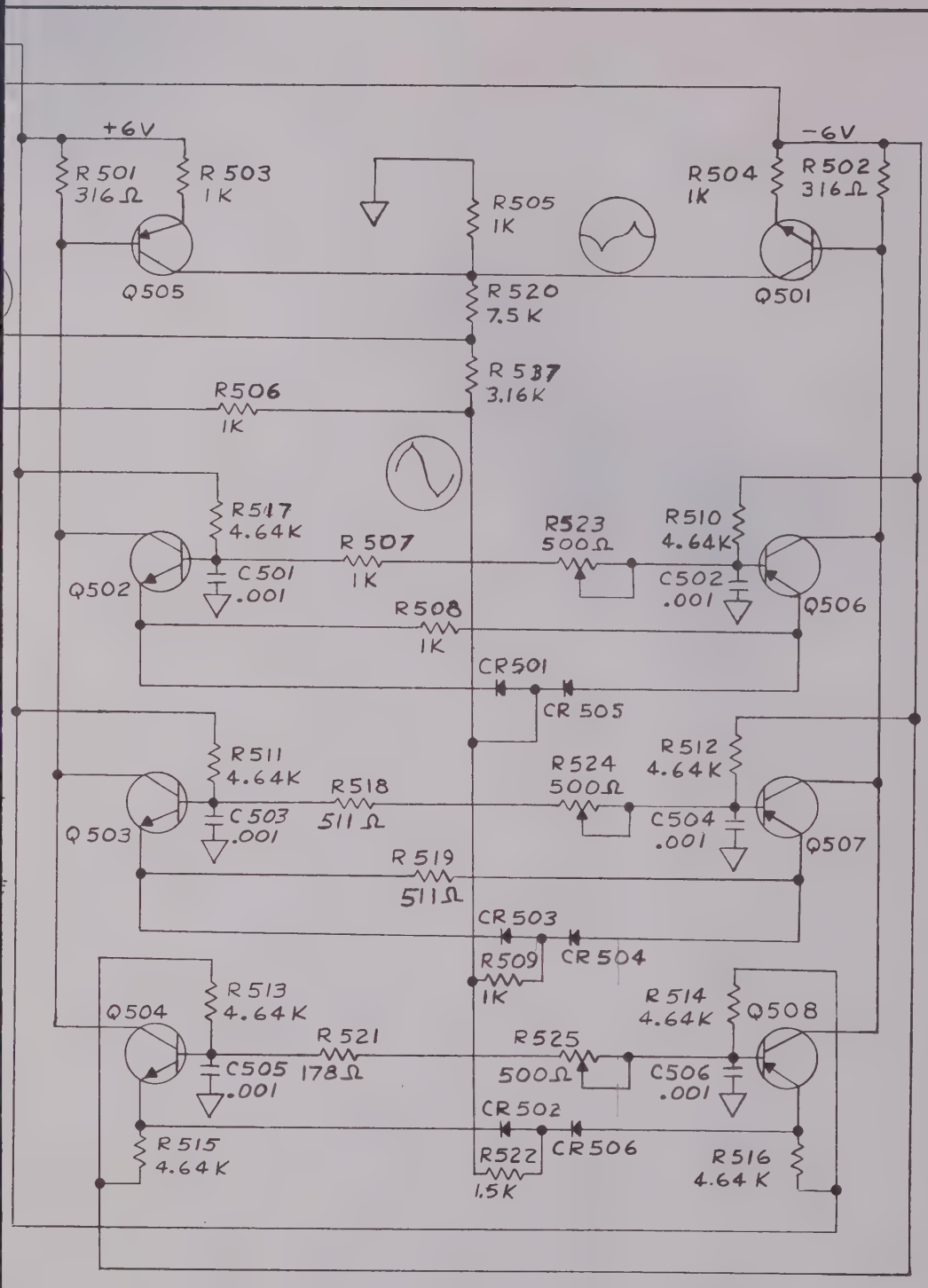

VOLTAGE REGULATOR
-6V
+6V
GRD
VCG INPUT
VCG AMPLIFIER
-7/-9 VOLTS
COM
+7/+9 VOLTS
BRN
BLK
RED
TO POWER SUPPLY
ORN
YEL
GRY
WHT
104
105
WHT/ORN
SHOWN IN MIDDLE POSITION
SW.
50Ω
CR1 IN3754
CR2 IN3754
CR3 IN751
CR4 IN3754
CR5 IN4009
CR6 IN4009
CR7 T1-51
CR8 T1-51
CR9 IN4009
CR10 T1-51
CR11 T1-51
Q1 2N1304
Q2 2N1305
Q3 2N1305
Q4 2N1305
Q5 2N1304
Q6 2N1304
Q7 2N1305
Q8 2N2257
Q9 2N711B
Q10 2N2257
Q11 2N711B
Q12 2N 2257
Q13 2N967
Q14 2N2257
Q15 2N967
Q16 2N1305
Q17 2N711B
Q18 2N 797
Q19 2N2714
Q20 2N1305
R1 4.7K
R2 4.7K
R3 100
R4 100
R5 68
R6 68
R7 1K
R8 1K
R9 1K
R10A 1.5K
R10B 1.5K
R11 1K
R12 27
R13 15K
R14 50
R15 470
R16 .1M
R17 2.87K
R21 390
R22 470
R23 470
R24 470
R25 560
R26 1.2K
R27 1.2K
R28 470
R29 220
R30 220
R31 470
R32 200
R33 560
R34 1K
R35 270K
R36 47K
R37 270K
R38 100
R39 100
R40 56
R41 47K
R42 220
R43 47K
R44 4.7K
R45 10
R46 10
R47 56
R48 82K
R49 10K
R50 47K
R51 220
R52 10K
R53 47K
R54 220
R55 4.7K
R56
R57
R58 10K
R59 18K
R60 270K
R99 47
R100 47
R103 270 K
R104 10K
R105
R106
R107 100K
R109 4.02K
R110 6.65K
R113 270
R114 680
C6 68pf
C7 68pf
C8 100 12V
C9 .1
C10 470pf
C11 470pf
C12 .1
C13 .1
C14 220pf
C15 220pf
C16 .1
C17 .01
C18 .01
C20 .01
C37 .01
C38 22pf
C39 10pf
C40 33pf
R101 47
NOTE: UNLESS OTHERWISE SPECIFIED.
1 ALL RESISTORS 1/2 W ± 10%
2 ALL RESISTANCE IN OHMS
3 ALL CAPACITANCE IN MICROFARADS
⚠ SELECTED FOR CALIBRATION
⚠2 SELECTED


FRONT PANEL
SW1-A
SW1-B
SW1-C
X.01
X.1
X1
X10
X100K
X10K
X100 X1K
FREQUENCY (CPS) AT SWITCH POSITIONS AS VIEWED FROM REAR
C1 10 1%
C2 .1 1%
C3 .001 1%
C4 82pf
C5 4-25 pf
SW2
R12 560 in 104
R20 1K in 105
500 in 104
R111 665K
R112 665K
R18 28.7K
R19 28.7K
WHT BLU BLK
TO 30V. AMP. in 105 only
105 104
ORN
SINE CONVERTER
ORN/WHT
ELCO CONNECTORS
RED BRN VIO VIO WHT BLU GRY BLK BLK
-6V
R63 47K
R68 220
R75 120
R76 470
Q31 2N1305
R90 270
270 in 104
R93 470 in 105
R115 100
Q23 2N967
Q21 2N2716
Q25 2N967
Q26 2N967
Q32 2N2257
Q33 2N2257
R91 1K
R94 27 in 105
10 in 104
C34 .001
C19 .33
Q35 2N1308
Q36 2N7118
R69 2.7K
R73 1K
R82 47
R81 120
R86 120
R89 10
R66 200K
R64 390K
C26 100pf
C31 100pf
39 in 104
R95 68 in 105
R61 390K
C22 330pf
R70 4.7K
C23 .01
R77 1K
C27 680 pf
R83 330
C32 330 pf
R92 47
C33 .01
R96 1K
C36 100 12V
C42 .5
R103 10
C41 .1
C35 .1
GRD
C28 1.0
R65 47K
R74 4.7K
R78 4.7K
C29 .1
R87 470K
Q34 2N1305
R62 270K
Q24 2N1305
Q29 2N 1305
Q22 2N2716
R84 10K
C21 .01
C25 .01
Q30 2N1304
Q27 2N1305
Q28 2N1305
C30 .01
R71 1K
R88 1K
C24 .33
R98 470K
R67 470K
R97 4.7K
R72 4.7K
R79 4.7K
R80 4.7K
THIS PRINT EFFECTIVE SER. NO. 437-451 AND 465 ON
WAVETEK
8133 engineer rd. san diego calif.
schematic
main board
models 104-105
C31-C113



NOTE

1. FOR OPTIMUM PERFORMANCE TRANSISTORS AND DIODES SHOULD BE MATCHED. SEE PARTS LIST FOR PART NUMBERS
2. PNP'S 2N1305 UNLESS NOTED
   NPN'S 2N1304 UNLESS NOTED
3. DIODES IN 4009
4. RESISTORS 1% UNLESS NOTED
5. SELECTED FOR 0 VDC OUTPUT
6. * INDICATES ½ W 10% CARBON



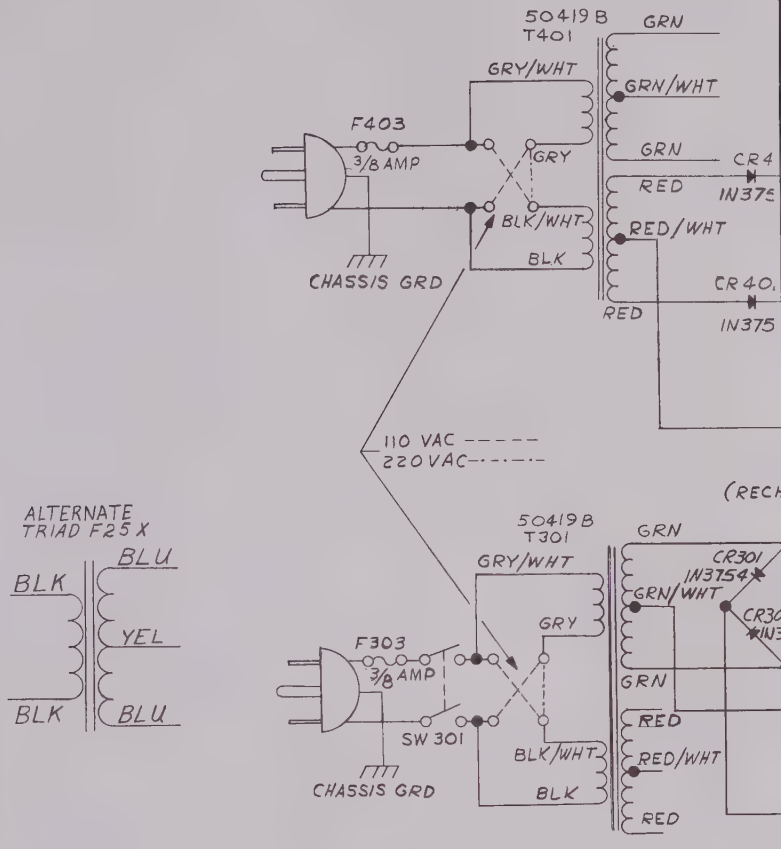
WAVETEK 8133 engineer rd. san diego, calif.

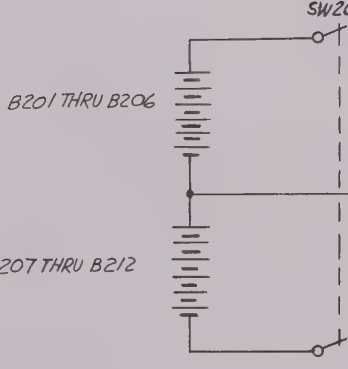
SCALE:	APPROVED BY: J. A. Main	DRAWN BY: JLP
DATE: 12/14/63		REVISED: JLH

sine converter

models 102 through 105

DRAWING NUMBER 031-004

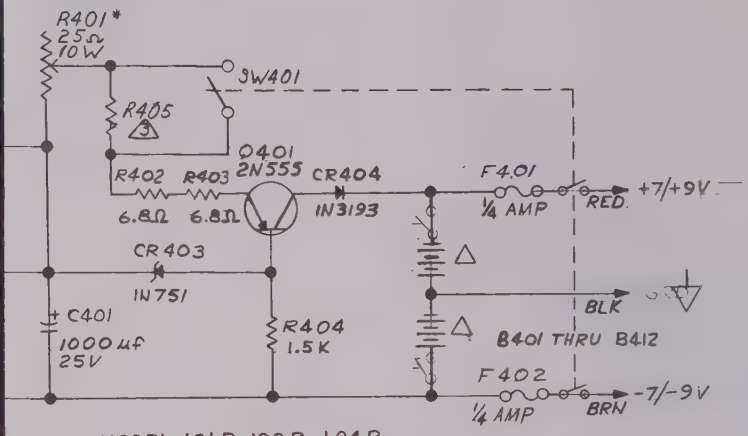




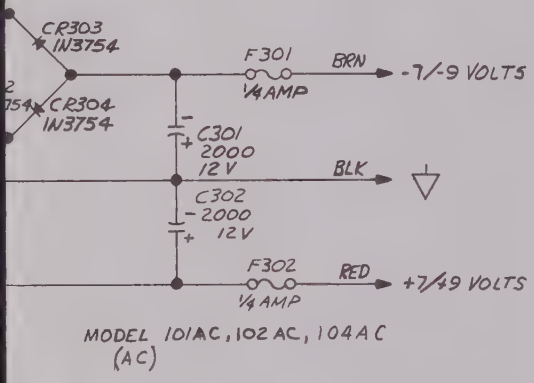
NOTE

1. △ 7.5 VOLT MAH NICAD BATTERIES EVEREADY Y613
2. * ADJUSTED FOR 30 MA CHARGE CURRENT (30 HR CHARGE). MAY BE ADJUSTED FOR 100 M CHARGE CURRENT BUT UNIT SHOULD NOT BE OPERATED FOR MORE THAN 14 HOURS WITH AC POWER TO AVOID OVERCHARGING BATTE
3. △ SELECTED FOR 5 MA. TRICKLE CHARGE CURRE

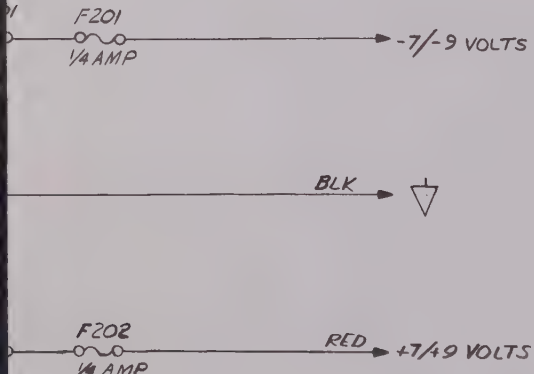
2XE34 PRINTED ON NO. 1600H CLEARPRINT



MODEL 101R, 102R, 104R
(RECHARGEABLE NICKEL-CADMIUM CELLS)

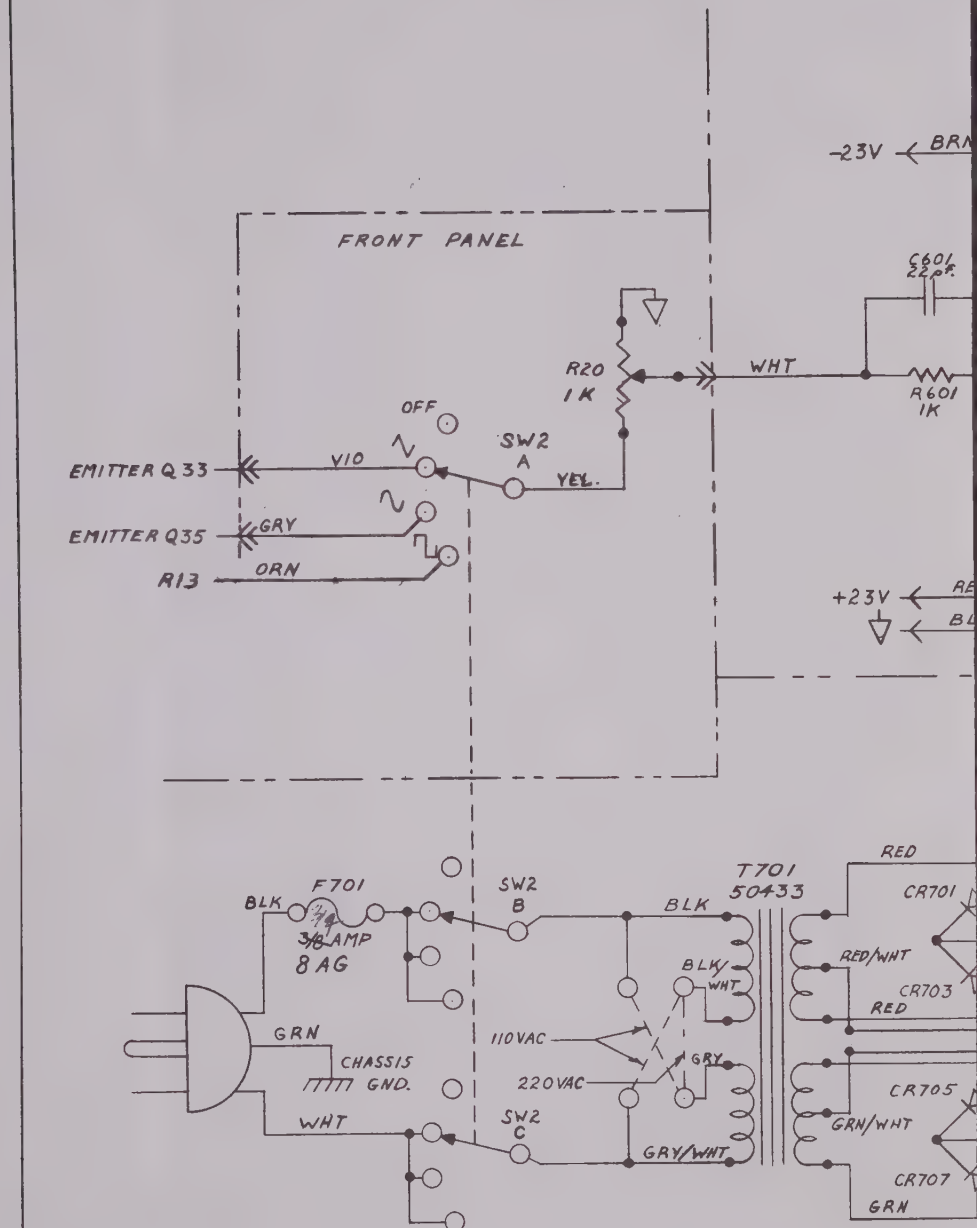


MODEL 101AC, 102AC, 104AC
(AC)



MODEL 101B, 102B, 104B
(BATTERY)

WAVETEK 8133 engineer rd. san diego, calif.		
SCALE: DATE: 12-15-63	APPROVED BY:	DRAWN BY: REVISED:
a.c.r. power supplies		
models 101, 102, 104		DRAWING NUMBER 031-005



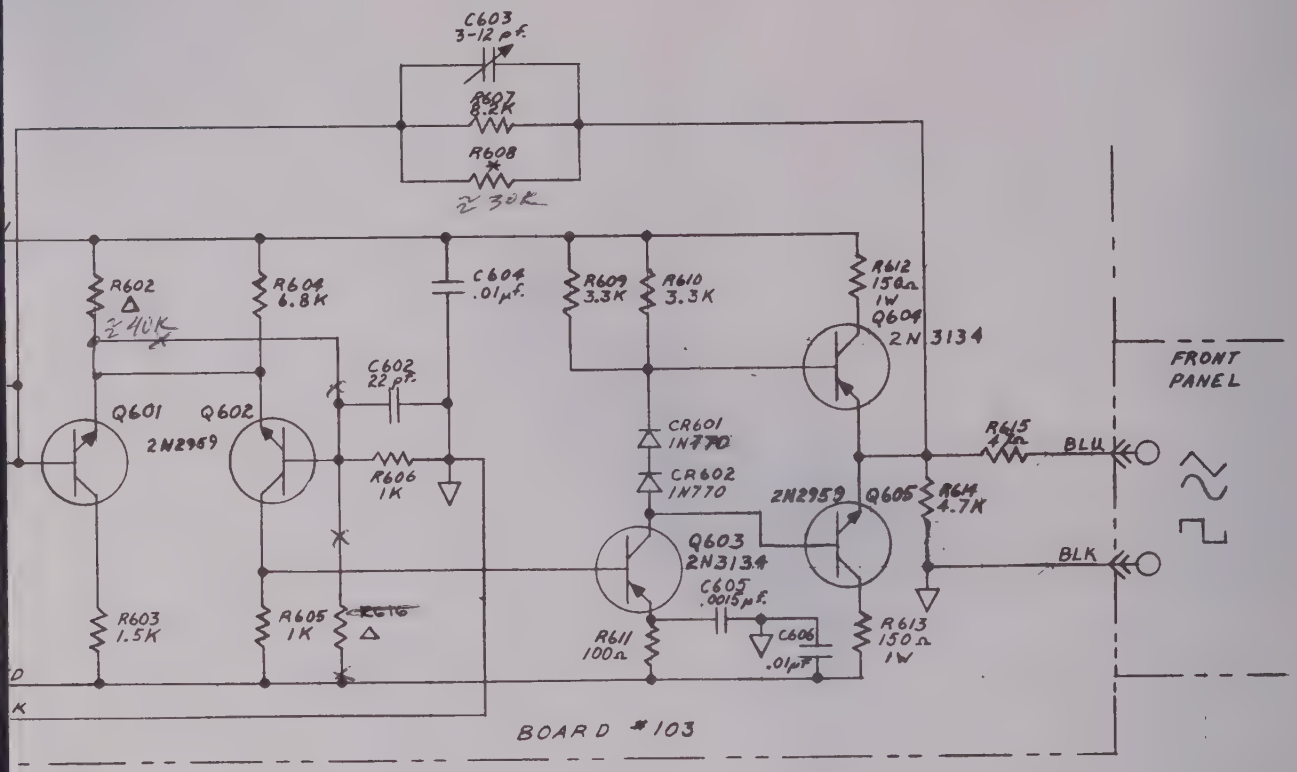
F702 thru F705 are 1/4 Amp 8AG

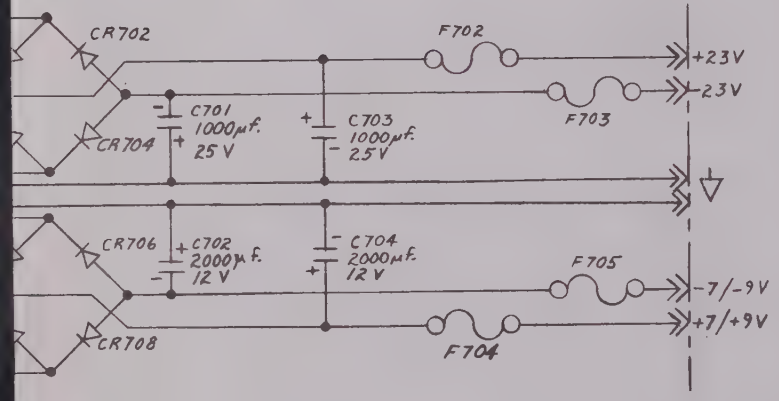
CR701 thru CR708 are 1N3754

△R602, R616 select for 0VDC offset.

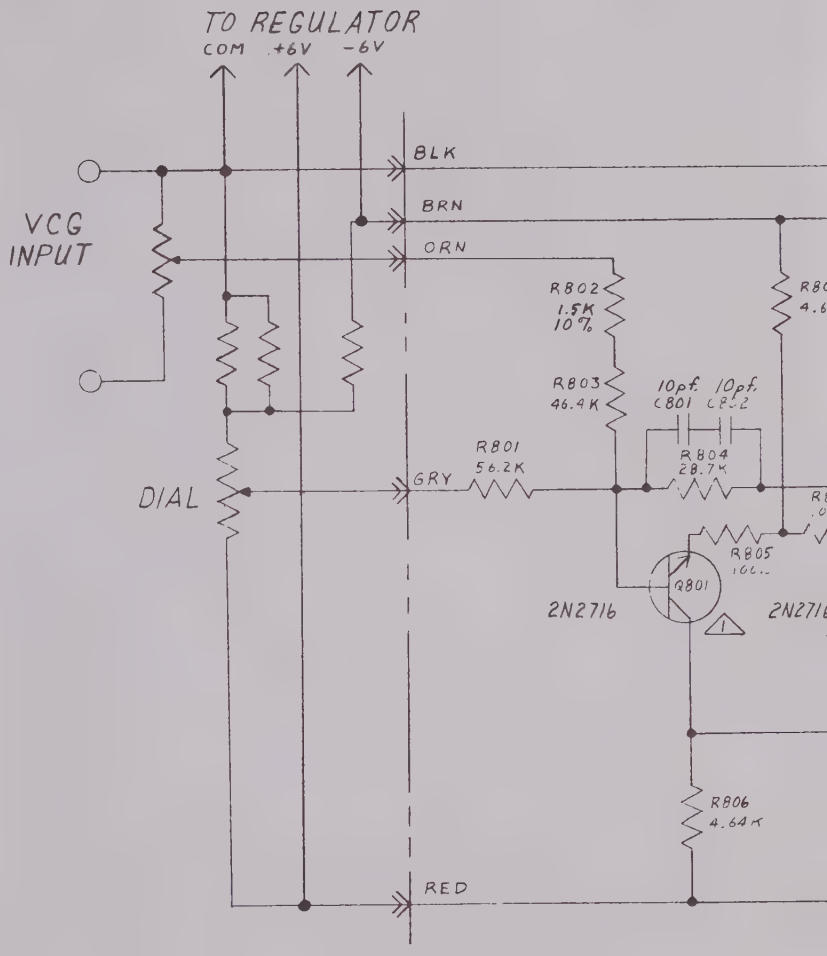
* R608 Select for 30V p-p output.

NOTE: Unless otherwise specified





WAVETEK	8133 engineer rd. san diego, calif.	
SCALE	APPROVED Maine	DFTMN. R. D. Collier
DATE 12/17/63		REVISED
30v amplifier and supply		
models 103, 105	031-006	



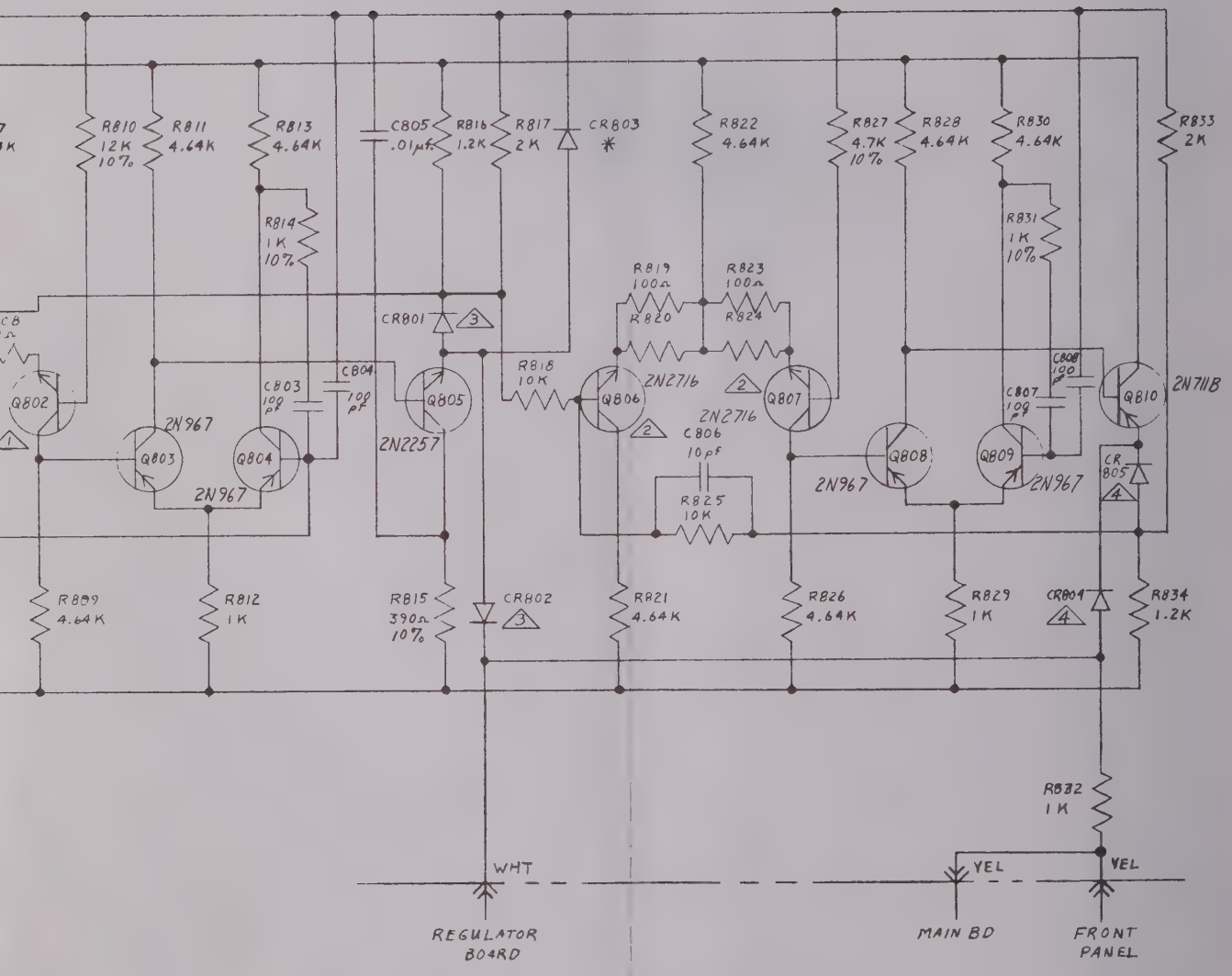
✳ SEE TEXT

△1 △2 △3 △4 MATCHED PAIRS

2. ALL DIODES IN4009

1. ALL RESISTORS METAL FILM ½W 1%

NOTES: UNLESS OTHERWISE SPECIFIED



WAVETEK	8133 engineer rd san diego calif.	
drn R. Collier 7-7-64	appr. J Maire	
vcg amplifier schematic		
models 104-105	031-007	

SECTION VII
MODEL 106, MODEL 107 ADDENDUM

SPECIFICATIONS AND GENERAL DESCRIPTION

The WAVETEK Models 106/107 Triggered Generators are essentially Models 102/103 Function Generators with the addition of Triggered operation in addition to normal operation. The generator circuitry in the Models 106/107 is identical to that in the Models 102/103.

Frequency, stability, accuracy, and distortion specifications are identical to those for the Models 102/103.

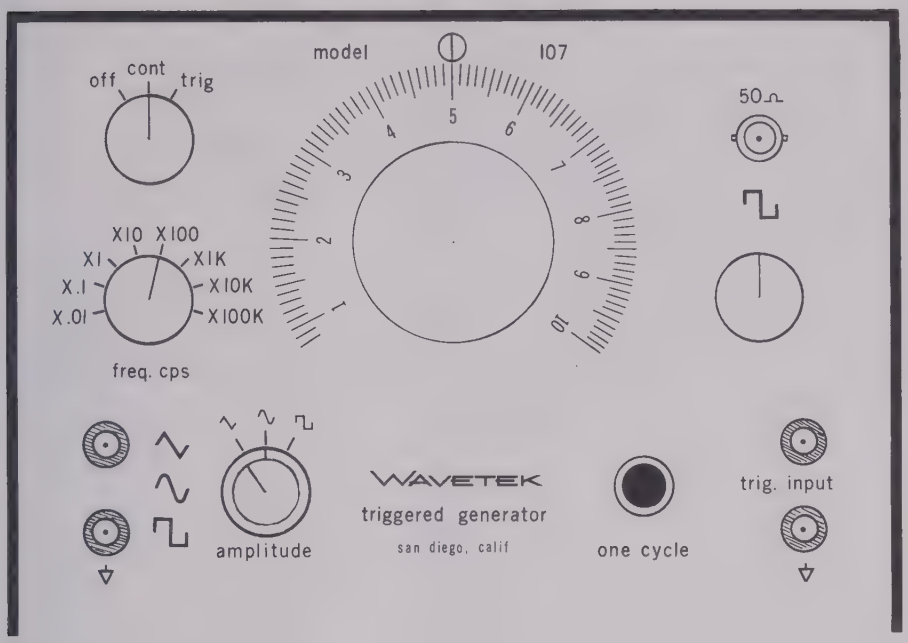
Output specifications for the Model 107 are identical to those for the Model 105.

Output specifications for the Model 106 are identical to those for the Model 104.

The Model 107, like the Models 103 and 105, is available only in the AC power version. The Model 106 is available in three versions - 106AC, 106B, and 106R, which are identical in power supply configuration and specification to the corresponding 102AC, 102B, 102R and in turn, the 104AC, 104B, and 104R.

Trigger specifications for the Models 106 and 107 are identical. External trigger required - 5 V; positive trigger standard but may be converted to negative trigger by changing one internal connection. Trigger input impedance - 1 K minimum. External trigger may be either a very fast pulse or a very slow rise time waveform. The frequency of oscillation in TRIGGERED and CONTINUOUS mode is dependent upon the setting of the frequency dial and range switch. The number of cycles generated in TRIGGERED mode is dependent upon the time duration of the external trigger input signal. Upon removal of the external trigger, the cycle then being generated will be completed. An internal push button is incorporated for generating single cycles. Models 106/107 will operate in the TRIGGERED mode from 0.008 cps to 100 Kc.

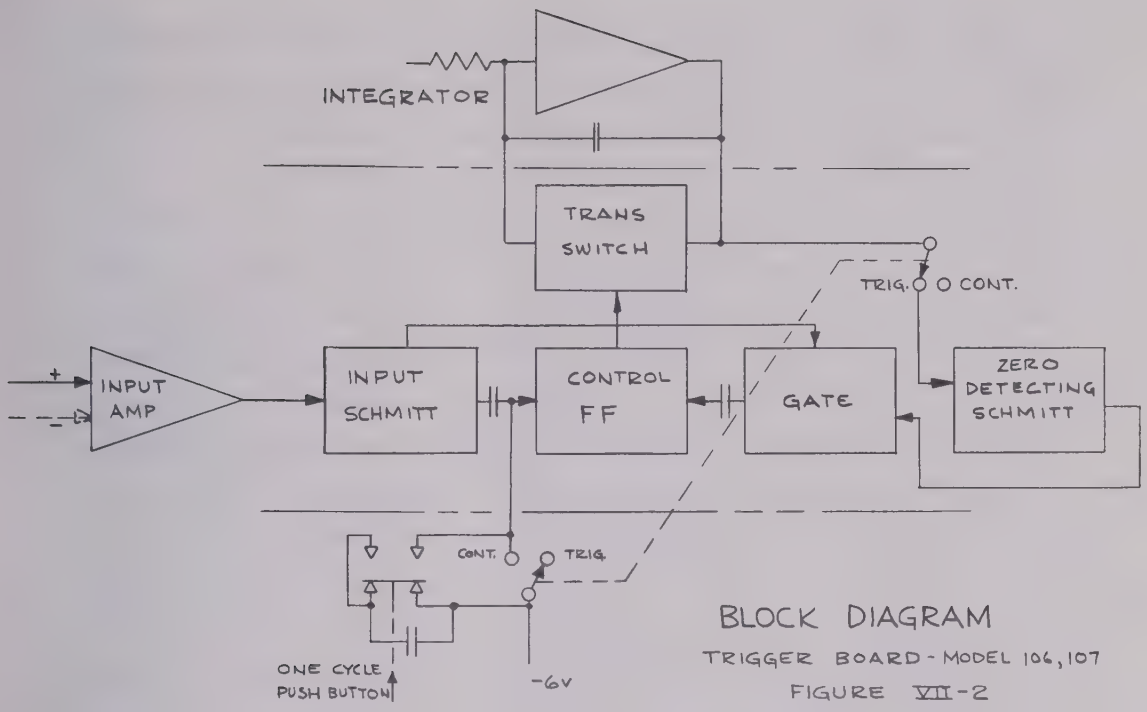
In the TRIGGERED mode, the sine and triangle waves start out in the positive direction in the Model 107 and start out in the negative direction in the Model 106.



OPERATING INSTRUCTIONS

Operation of the Models 106/107 is identical to that of the Models 104/105 except that the frequency dial multiplier has been replaced by the CONTINUOUS TRIGGERED Mode selector switch, and the VCG input and associated attenuator have been replaced by the TRIGGERED input and one-cycle push button. In the CONTINUOUS Mode, continuous waveforms are generated. When the unit is switched to TRIGGERED Mode, the cycle being generated will be completed. The sine and triangle waves will then be clamped to ground. Upon receipt of a trigger pulse, oscillations commence, sine and triangle waves immediately going positive (107), or negative (106). If the duration of the trigger pulse is less than 3/4 of a cycle, one cycle will be completed ending at ground and remaining at ground until the next trigger is received. The square wave output will flip to positive (107), or negative (106), at the 90° point and back to negative (107), or positive (106), at the 270° point. Note the one volt, 50 ohm square wave output will be identical in phase to that of the 106. Should the trigger pulse be longer in duration than the 3/4 cycle mentioned, the oscillator will continue to operate until the trigger, (gate), is removed. After removal of the gate, oscillations will continue until the

existing cycle is completed at which point output will again be ground. The ground output referred to will always be well less than 1 % of max peak to peak output. The frequency of oscillation is determined by the setting of the range switch and the frequency dial. Upon switching back to CONTINUOUS Mode, continuous oscillations will commence.



BLOCK DIAGRAM
TRIGGER BOARD - MODEL 106,107
FIGURE VII-2

THEORY OF OPERATION

Figure VII-2 is a block diagram of the Trigger Board used in the Models 106/107. A transistor switch is connected across the integrator used in the basic generator. When the switch is open, the generator oscillates in typical fashion. When the switch is closed, the integrator is shorted and its output voltage is within a few millivolts of ground. If the transistor switch is opened and closed when the integrator output is near ground, the other flip flops used in the basic generator will not be affected and thus there will just be a cessation of oscillation during the time the switch is closed; but oscillations will commence again immediately upon opening of the transistor switch. During the time the transistor switch is closed, it is required to pass the integration current which would otherwise put a charge on the integrating capacitor.

The external input trigger is amplified by the input differential amplifier which in turn fires the input Schmitt Trigger when the input reaches a predetermined level. The firing of the Schmitt switches the control flip

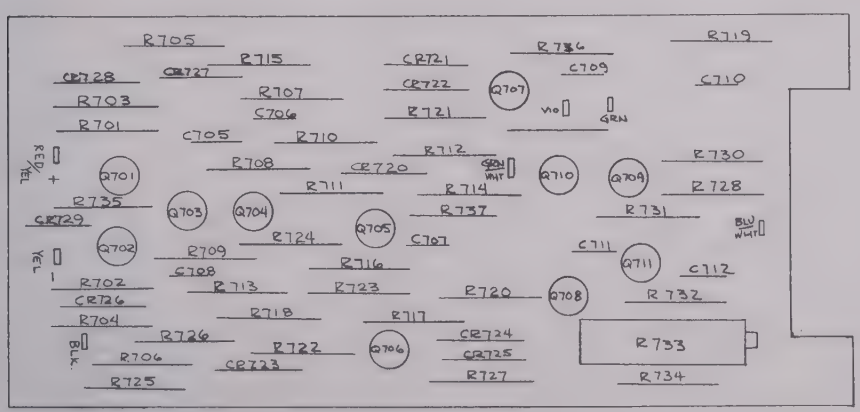
flop which opens the transistor switch and the basic generator commences oscillation. After completing slightly more than 1/2 cycle oscillation, the zero detecting Schmitt sets. At the completion of the cycle when the output of the integrator reaches ground, approaching from a positive direction, the zero detecting Schmitt will reset. This reset pulse will switch the control flip flop back to close the transistor switch and oscillation of the basic generator will stop. The reset pulse of the zero detecting Schmitt is passed through a gate which is controlled by the input Schmitt. Should the external input trigger be a gate rather than a narrow trigger pulse, the input Schmitt will gate out the reset pulse from the zero detecting Schmitt and thus oscillations will continue until the external gate is removed.

The CONTINUOUS-TRIGGERED Mode switch has two functions. In CONTINUOUS, it locks the control flip flop so that the transistor switch is held open. In TRIGGERED, this lock-out is removed and the zero detecting Schmitt is connected to the output of the integrator. A manual push button is incorporated for single cycle generation. Pressing of the switch momentarily provides a pulse to fire the control flip flop and open the transistor switch; the transistor switch being closed at the completion of one cycle by the reset pulse from the zero detecting Schmitt. Note: The one-cycle push button must be released to discharge the capacitor before another cycle can be triggered.

MAINTENANCE

The Schmitt Triggers, control flip flop, input amplifier and gate are all of conventional design and the only maintenance required would be in the case of a malfunction as a result of a faulty component. The only adjustment incorporated is a pot (R733) controlling the firing point of the zero detecting Schmitt. This should be adjusted so that the Schmitt fires exactly at the zero cross over of the integrator output. If this is not in proper adjustment, the completion of the cycle will occur with a short transient resulting from either triggering too soon or too late. When properly adjusted, the end-of-cycle transition to ground will be smooth without transient for all but the very highest frequencies.

The only unique circuitry used is that of the transistor switch. The switching transistor Q710 is normally held biased off by current from the constant current generator, Q708. The control flip flop, Q705-Q706, controls constant current generator Q707. Closing of the transistor switch Q710 is accomplished by a negative voltage on the collector of Q705 which will turn constant current generator Q707 on. The constant current generated by Q707 overcomes that generated by Q708 and also supplies turn on current to the transistor switch Q710 thus shorting the integrator. Note: The base and emitter of the transistor switch Q710 ride on the output of the integrator. When the transistor switch is closed the base and emitter current of Q710 flow to the output of the integrator, a low impedance source.



TRIGGER BOARD — MODEL 106, 107

PARTS LIST

CAPACITORS

Tolerance ± 10% unless otherwise indicated.

CKT. NO.			DESCRIPTION	PART NO.	MFG.
C43	100 pfd	Cer	1000 v	DD101	CRL
C705	220 pfd	Cer	1000 v	DD221	CRL
C706	330 pfd	Cer	1000 v	DD331	CRL
C707	68 pfd	Cer	1000 v	DD680	CRL
C708	330 pfd	Cer	1000 v	DD331	CRL
C709	.001 mfd	Cer	1000 v	DD102	CRL
C710	100 pfd	Cer	1000 v	DD101	CRL
C711	330 pfd	Cer	1000 v	DD331	CRL
C712	330 pfd	Cer	1000 v	DD331	CRL

DIODES

CR720	1N4009				GE
CR721	1N4009				GE
CR722	1N4009				GE
CR723	1N4009				GE
CR724	1N4009				GE
CR725	1N4009				GE
CR726	1N4009				GE
CR727	1N4009				GE
CR728	1N4009				GE
CR729	1N4009				GE

TRANSISTORS

Q701	16J1				GE
Q702	2N967				MOT
Q703	16J1				GE
Q704	16J1				GE
Q705	16J1				GE
Q706	16J1				GE
Q707	2N967				MOT
Q708	16J1				GE
Q709	16J1				GE
Q710	2N2714				GE
Q711	16J1				GE

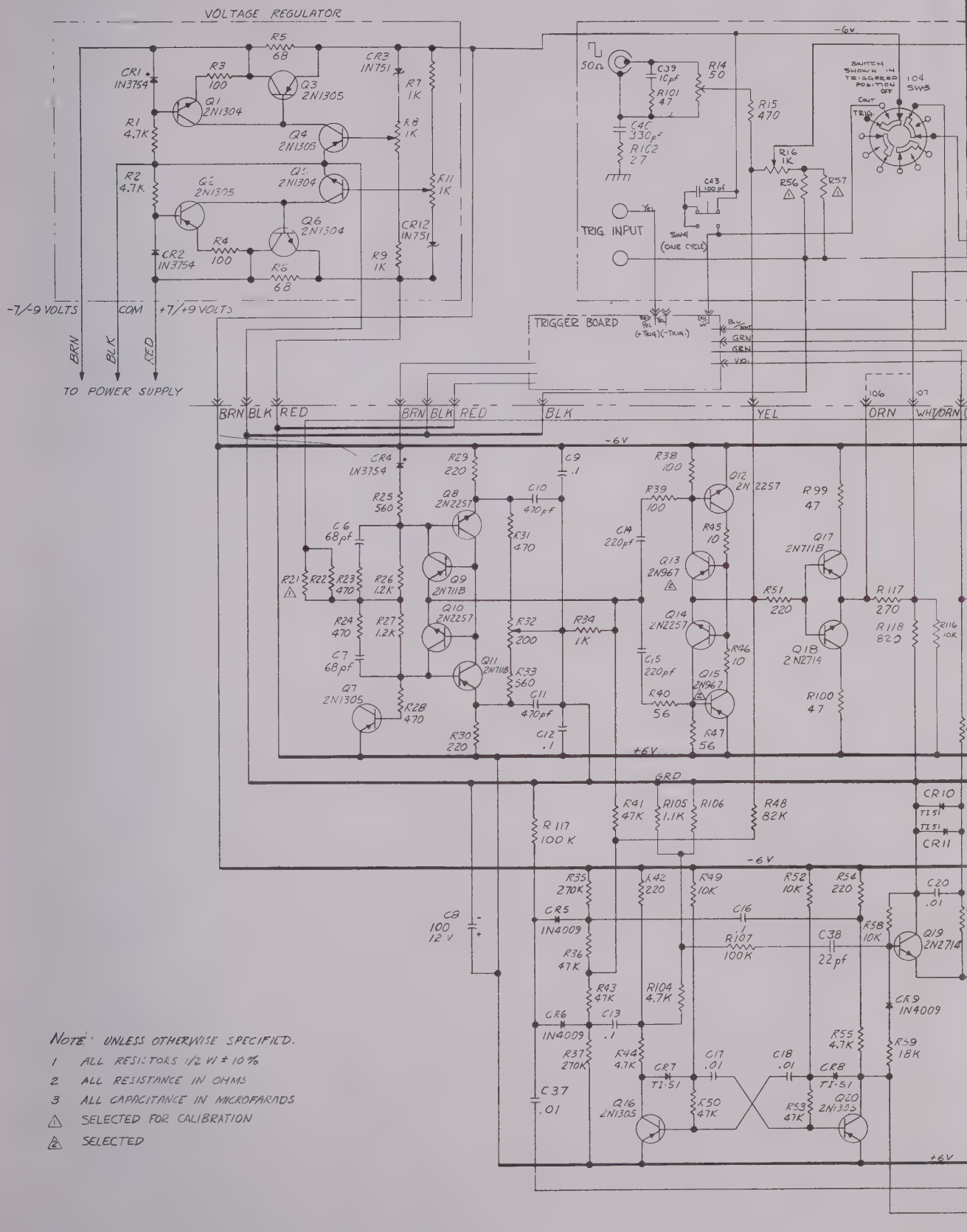
RESISTORS

Resistors are fixed composition, 1/2W, ± 10%, AB unless otherwise indicated.

CKT. NO.	DESCRIPTION	PART NO.	MFG.
R701	1K		
R702	2.2K		
R703	4.7K		
R704	2.2K		
R705	10K		
R706	2.2K		
R707	820 ohm		
R708	12K		
R709	1.5K		
R710	1.5K		
R711	33K		
R712	15K		
R713	33K		
R714	820 ohm		
R715	15K		
R716	10K		
R717	10K		
R718	1K		
R719	47K		
R720	1K		
R721	1.5K		
R722	33K		
R723	15K		
R724	33K		
R725	22K		
R726	4.7K		
R727	270 ohm		
R728	47 ohm		
R729	1.8K		
R730	1K		
R731	1K		
R732	1K		
R733	5K	W.W. Var.	BOR
R734	27K		
R735	3.3K		
R736	330 ohm		
R737	1K		

SWITCHES

SW1	Push Button		Spectrol

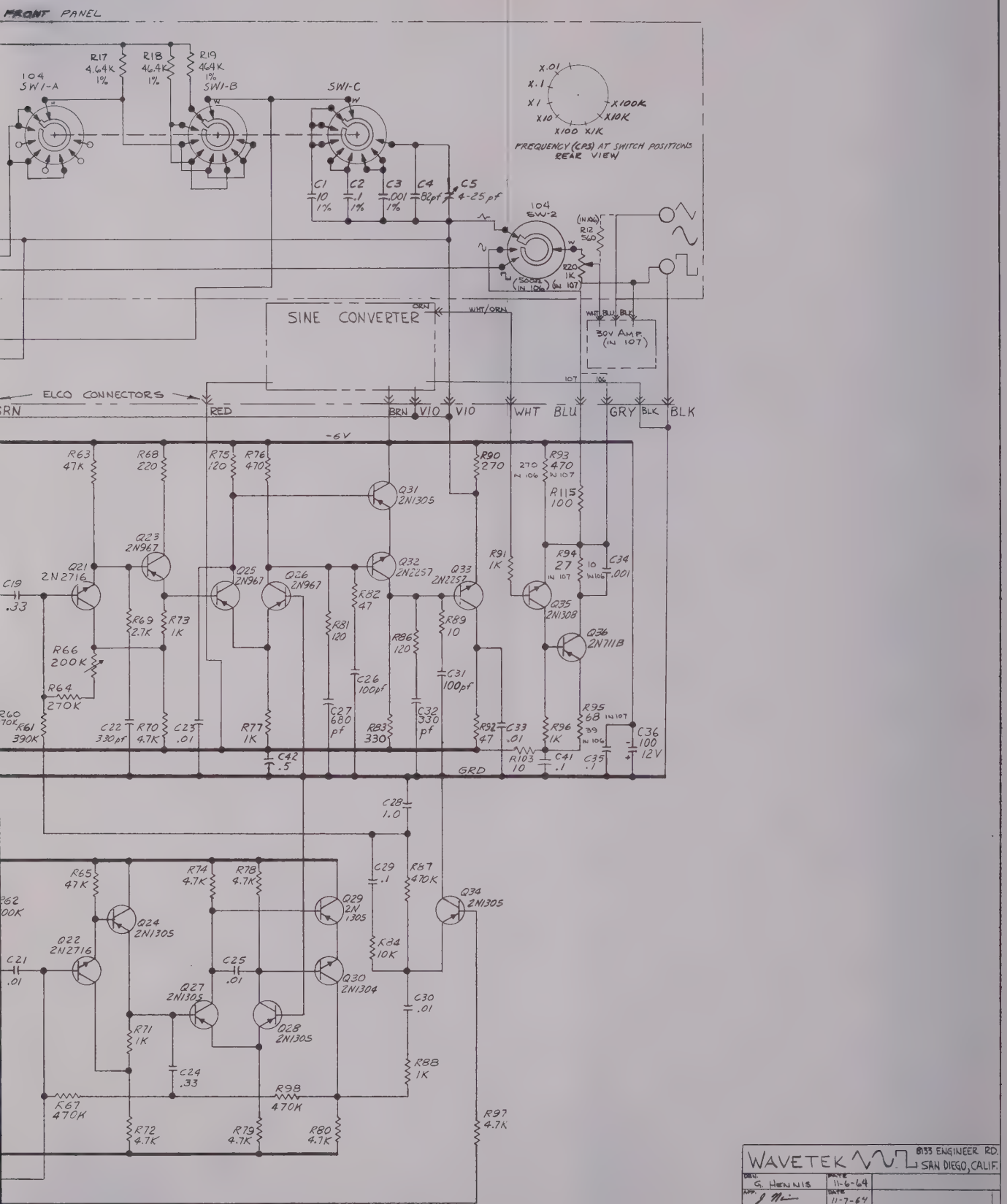


NOTE: UNLESS OTHERWISE SPECIFIED.

1. ALL RESISTORS 1/2 W ± 10%
2. ALL RESISTANCE IN OHMS
3. ALL CAPACITANCE IN MICROFARADS

△ SELECTED FOR CALIBRATION

△2 SELECTED

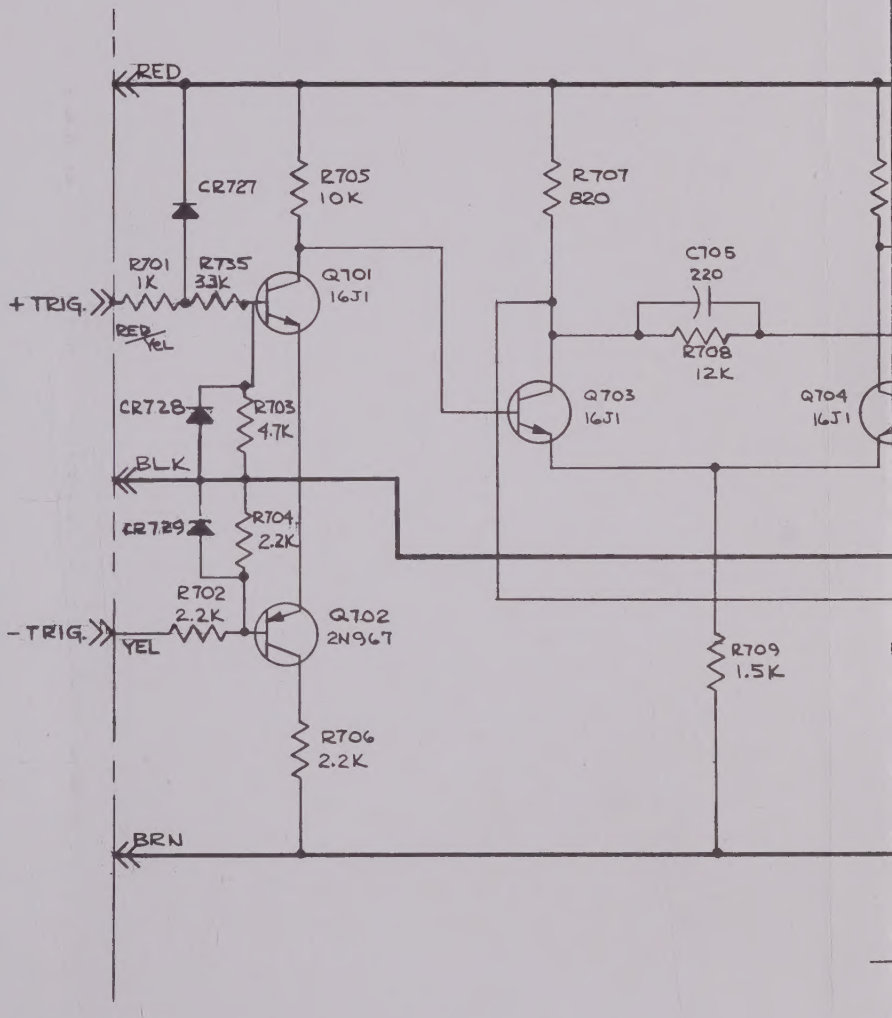


WAVETEK 8733 ENGINEER RD. SAN DIEGO, CALIF.

DRN. G. HENNIS	DATE 11-6-64	
APP.	DATE 11-7-64	

SCHEMATIC- MAIN BOARD

MODELS 106/107 | 031-008

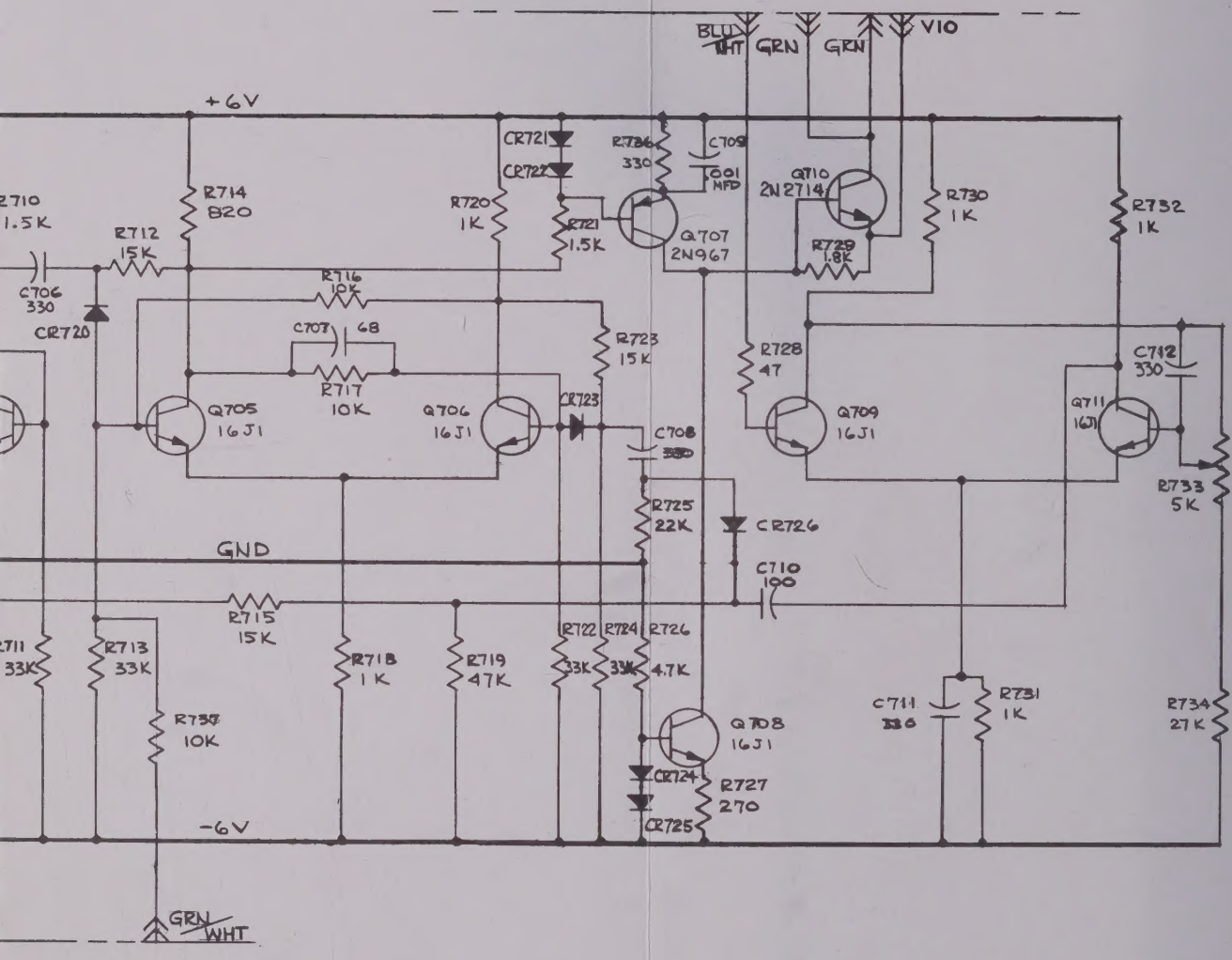


3 ALL DIODES IN4009

2. ALL CAPACITANCE IN PICOFARADS

1. ALL RESISTORS ½W 10%, RESISTANCE IN OHMS

NOTES: UNLESS OTHERWISE SPECIFIED



WAVETEK			8133 engineer rd. san diego, calif.
DRN. G. HENNIS	12-4-64	APP. J Main	DATE 12-5-64
SCHEMATIC, TRIGGER BOARD			
MODELS 106, 107		017 - 011	

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